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CONTENTS.

PAGE

Moles and their Like. By R. LYDEKKER, B.A.Cantab. ... 81
Stellar Spectra and Stellar Velocities. By Miss A. M. CLERKE 84
Caterpillars' Dwellings—II. By E. A. BUTLER 85
The Nuthatch. By HARRY F. WITHERBY 87
Letters:—VINCENT YARDLEY; H. BECK; T. H. MADDY; J. J. ALEXANDER; C. TOMLINSON 88
What is a Star Cluster? By A. C. RANYARD 90
Science Notes 92
Deep Sea Deposits.—Third Paper. By the Rev. H. N. HUTCHINSON, B.A., F.G.S. 94
On certain Low-lying Meteors. By CHARLES TOMLINSON, F.R.S., F.C.S., &c. 96
The Face of the Sky for May. By HERBERT SADLER, F.R.A.S. 99
Chess Column. By C. D. LOCOCK, B.A.Oxon. 99

MOLES AND THEIR LIKE.

By R. LYDEKKER, B.A.Cantab.

IT is probably well known to most of our readers that in the evolution of organized nature two great factors have constantly been working against each other—the one being the adherence to a particular type of structure, while the other is the adaptation to a special mode of life. The usual resultant of these two forces has been that, in any assembly of animals specially adapted for a certain peculiar kind of existence, while internally its different members have preserved their essential structural peculiarities more or less intact, externally they have become so much like one another that it often requires the aid of the professed zoologist to point out their essential distinctness. Perhaps in no case is this adaptive similarity in external characters better displayed than among certain of the smaller mammals which have taken to a more or less completely subterranean burrowing existence, of which the common mole is the best known example. In the British Islands we have, indeed, only this one creature which has adopted this particular mode of life; and it is to this animal alone that the name "mole" properly belongs. Other parts of the world possess, however, several more or less closely allied animals to which the same name must clearly be also applied. If, however, we happen to have friends from the Cape, we may hear them applying the name "moles" to certain burrowing mammals from that district, which upon examination would be found to differ essentially in structure both from the ordinary moles and from one another. Then, again, if we were to travel in Afghanistan or some of the neighbouring regions, we should meet with another mole-like burrowing animal to which we should likewise feel disposed to apply the same name, although it has not the most remote kinship with our English mole. Finally, the deserts of central South Australia are the dwelling-place of the recently discovered "marsupial mole," which, although mole-like in general form, differs from all the animals yet mentioned in belonging to the marsupial order.

We thus arrive at the conclusion that in the popular sense the term "mole" now serves to indicate a number of widely different animals, whose sole or chief bond of union is to be found in their adaptation to a similar mode of life, and their consequent assumption of a more or less similar outward form. Hence, in order to avoid confusion, it will be necessary to prefix the epithet "true" to those species which belong to the same friendly group as the "little gentleman in black velvet," while the remainder must be designated by other distinctive epithets. It might have been thought that such an expanded application of the name "mole" was restricted to popular language. This, however, is not the case, as naturalists have found it convenient to adopt the names "sand mole," "golden mole," "marsupial mole," etc., as the distinctive titles of different members of this purely artificial assemblage of animals; and the reader will accordingly understand that when we speak of "moles and their like," we merely refer to a similarity in habits, and a more or less marked external resemblance between the animals under consideration.

The general bodily form of the common mole is so thoroughly well known and familiar, that the term "mole-like" has been introduced into zoological, if not into popular, literature as a definite descriptive epithet. Since it is perfectly obvious that this peculiar form is the one best adapted for the needs of the creature's subterranean existence, no explanation is necessary why most of the other members of the assemblage have conformed more or less closely to this type. We may especially notice the flat, tapering, and sharp-nosed head, passing backwards without any distinctly defined neck into the long and cylindrical body; the comparative shortness of the limbs and the immense strength of the front pair, which are placed close to the head, and have their feet expanded into broad, shovel-like organs. We shall also not fail to observe the absence of any external conchs to the ears, and the rudimentary condition of the deeply-buried eyes. A long tail would also be useless to a burrowing animal, and we accordingly find this appendage reduced to very small dimensions; while the close velvety hair is most admirably adapted to prevent any adhesion of earthy particles during the mole's subterranean journeys. Equally well-marked adaptive peculiarities would also present themselves were we to undertake an examination of the mole's skeleton. While the majority of the assemblage conform more or less closely to the true moles in appearance, there are others in which such resemblance is but slightly marked, if apparent at all, from which we may probably infer some minor differences in their mode of life.

Proceeding to the consideration of the different groups of mole-like animals, it will be convenient to divide the mixed assemblage into insectivorous moles, rodent moles, and marsupial moles. The term "insectivorous moles," it may be premised, does not primarily indicate carnivorous habits in the species thus designated, but merely refers to the fact that they are members of the order Insectivora. It would of course be impossible, not to say out of place, to attempt a definition of that order; but it may be mentioned that it includes small mammals, like shrews, moles, and hedgehogs, which differ from the rodents in not pos-

sessing a pair of chisel-like teeth in the front of the jaws, and also have their molar teeth surmounted by a number of small sharp cusps.

The insectivorous moles include not only our common

Fig. 1.—The Cape Golden Mole.

mole (*Talpa europæa*), but also many other species belonging to the same genus, as well as certain others which are referred to distinct genera, all of which, for our present purpose, may be collectively spoken of as true moles. Of these, two genera (*Talpa* and *Scaptonyx*) inhabit Europe and Asia, while the other three are North American; Africa having no representatives of the group. It may be well to mention that all the true moles have very broad naked hands, each furnished with five toes carrying long flattened nails, in addition to which there is a sickle-like extra bone internally to the thumb. In burrowing, most of them throw up the well-known molehills at certain intervals from the tunnels driven in search of worms—their chief food.

In addition to these true moles, North America also possesses certain other species known as shrew moles, which, while belonging to the same family (*Talpidæ*), are distinguished by the absence of the sickle-like bone in the hand and the less expanded form of the bones of the upper part of the fore-limb. They are thus clearly seen to be less specialized creatures than our own mole, to which they closely approximate in general appearance.

Although belonging to the insectivorous order, the mole-like creature represented in the foregoing figure indicates a totally different family group. If we were to examine the upper molar teeth of a common mole, we should find that they had broad crowns, carrying cusps arranged somewhat after the manner of the letter W. On the other hand, in the Cape golden mole (as the animal represented above is termed) the corresponding teeth have triangular crowns carrying three cusps arranged in a V. Moreover, if we look at the fore-limb, we find instead of the five-fingered hand of the mole that there are but four digits, of which the lateral pair are small, while the two middle ones are enlarged and furnished with triangular claws of great power. As in the true moles, all external traces of ears and eyes are concealed by the fur; this latter, it may be added, having a peculiar golden-green metallic lustre, from which the name of the animal is derived. The golden moles, of which there are several species, are much smaller than our English mole, and are widely distributed in South Africa; in which continent they, in conjunction with the under-mentioned sand mole and its allies, take the place occupied in the northern hemisphere by the true moles. In tunnelling, the golden moles come so close to the surface as to leave a ridge marking their course. The true moles and the golden moles afford us, therefore, an instance of two entirely distinct groups belonging to the same order having assumed a perfectly similar mode of life, and, consequently, having acquired a superficial general similarity in external appearance.

With the rodent moles, of which there is likewise more than a single group, we come to animals of a totally different order, which have assumed mole-like forms and habits, and are popularly confounded with the true moles. In common with the other members of the order Rodentia, all these rodent moles are characterized by the presence of a pair of powerful chisel-like incisor teeth in the front of each jaw, while their molars have broad and flattened crowns adapted for grinding. Moreover, instead of driving their tunnels in search of worms, these rodent moles burrow for roots and bulbs. All of them have very small or rudimentary ears and eyes, large and powerful claws, and short tails.

One of the best known of these rodent moles is the great mole-rat (*Spalax*), ranging from south-eastern Europe to Persia and Egypt, in which the eyes are completely covered with skin; allied to which are the bamboo-rats (*Rhizomys*) of north-eastern Africa and Asia, distinguished by having minute uncovered eyes and small naked ear-conchs, and thus departing more widely from the mole type. In the sandy soil of Egypt the mole-rat constructs tunnels of great length in search of bulbs. In South Africa these forms are replaced by the huge sand mole (*Bathyergus*), which attains a length of about ten inches; and also by certain smaller animals known as *Georychus* and *Myoscalops*, which differ from the former by the absence of grooves in their incisor teeth. This sand mole is commonly met with in the flats near the shore, while the smaller forms generally frequent land at a higher elevation. Sometimes, however, both are found together, and the country is then covered in all directions with hillocks precisely resembling those made by our English mole. Although the sand mole has uncovered eyes, these are not bigger than the heads of large pins, and can have but little visual power. Still, however, their presence serves to indicate that these animals have not become so completely adapted to a subterranean life as has the common mole; and this is confirmed by the fact that if their burrows are opened, the sand moles after a few minutes usually protrude their noses from the aperture with a view to discover the cause of the disturbance, whereas an ordinary mole would under similar circumstances remain below.

Fig. 2.—The Long-clawed Mole-Vole.

All the foregoing belong to one family of rodents; but in addition to these certain members of the Vole group (a

sub-division of the *Muridæ*) have also taken to a subterranean burrowing life, * with the assumption of a mole-like bodily form. These may be termed mole-voles, and range from Russia to central and northern Asia, where they are represented by the two genera *Ellobius* and *Siphneus*. They all have mole-like heads and bodies, short limbs and tails, rudimental external ears, very minute eyes, and powerful fore-paws. In the Russian mole-vole (*Ellobius*) and the allied Quetta mole from Afghanistan the claws of the front paws are short; but, as shown in our figure, they become greatly elongated in the members of the genus *Siphneus*. All of them agree with the ordinary voles in the peculiar structure of their molar teeth, which consist of a number of triangular prisms placed edge to edge. All these animals are described as driving subterranean tunnels and throwing out at intervals heaps of earth precisely after the fashion of the common mole.

The foregoing are the only rodents which have assumed a more or less distinctly marked mole-like external form while retaining all the characteristic structural features of the order to which they belong. There are, however, two other members of the same great order which, while having acquired mole-like habits, have not assumed a distinctly mole-like form. One of these is the tuco-tuco (*Ctenomys*) of South America, belonging to the same great family as the capybara and the coypu. This animal is rather smaller than a rat, with a relatively shorter tail, pale grey fur, and red incisor teeth. Its general form is also not unlike that of a rat, the limbs being of fair length, and the front paws not markedly enlarged, while the eyes are of considerable size. The external conchs of the ears have, however, been greatly diminished in size. The tuco-tuco derives its name from its voice, which resounds day and night from its subterranean dwellings, and is compared by Mr. W. H. Hudson to the blows of a hammer on an anvil. It frequents loose and sandy soil, although occasionally found in moist heavy mould, through which it pierces its way as readily as the mole. Darwin, who states that the tuco-tuco is even more subterranean in its habits than the mole, was told by the Spaniards that blind examples were often captured. This, however, is not the experience of Mr. Hudson, who lays stress on the relatively large size of the creature's eyes. From the soft nature of the soil in which it tunnels, it is not difficult to understand why it has been unnecessary for the tuco-tuco to assume a mole-like bodily form; but the reason for the retention of fully-developed eyes—which we should have thought exceedingly prone to injury—is hard indeed to divine.

The other rodents with mole-like habits are two tiny little creatures from the sandy districts of Somaliland, locally known by the name of farumfer, and scientifically as *Heterocephalus*. They are about the size of a mouse, with large hands, moderately long tails, long powerful fore-feet, no external ear-conchs, minute eyes, and the whole skin naked, save for a few sparse bristly hairs. About as ugly a creature as can well be conceived, the farumfer, if clothed with a thick coat of fur, would be not very unlike a rather long-tailed, long-limbed, and narrow-handed mole. For tunnelling beneath the hot sand of the Somali desert the naked skin of the farumfer is most admirably adapted; and as the creature is allied to the South African *Georychus*, it may be regarded as the member of this group most specially adapted for a subterranean existence. Mr. E. L. Phillips, who was the first to observe these curious rodents in the living state, writes that they threw up in certain districts groups of elevations in the sand which may be compared to miniature volcanic craters. When the animals are at work the loose sand from their tunnels is brought to the bottom of the crater and sent with considerable force into the air with a succession of rapid jerks, the rodents themselves remaining concealed in the shelter of their burrows, from which they appear never to venture forth.

As we have had occasion to notice in a previous article, the extensive assemblage of pouched or marsupial mammals contains groups corresponding to several of those of the placental or higher mammals. Thus, for instance, the kangaroos in Australia play the same *rôle* as the deer and ruminants in other parts of the world, while the Tasmanian wolf takes the place of the ordinary wolf, the wombats act the part of the marmots, the phalangers of squirrels, and the bandicoots of the civets and weasels. Till quite recently it was thought that the place of the moles (whether insectivorous or rodent) was unoccupied in the Antipodes, and that no marsupial had adapted itself to a tunnelling subterranean existence. Within the last few years it has, however, been discovered that the sandy deserts of south central Australia are inhabited by a small burrowing creature belonging to the pouched group, which has been fitly termed the marsupial mole (*Notoryctes*);

FIG. 3.—Under surface of the Marsupial Mole, two-thirds natural size. (After Stirling.)

and it is not a little remarkable that in general appearance this tiny animal is even more mole-like than are some of the above-mentioned burrowing rodents, thus showing how all powerful is adaptation to environment, and of how little import is internal structure in modifying the external form of an animal. The general mole-like appearance of the Australian burrower will be apparent from the accompanying figure; the most striking mole-like features being the elongated and depressed body passing imperceptibly into the head, the absence of external ear-conchs, the rudimentary pin-like eyes, the small tail, and the short limbs, of which the front pair are armed with claws of great power. The marsupial mole stands alone, however, in having the front of the muzzle protected by a leathery shield; while its short and blunt tail is also covered with a peculiar naked leathery skin. In the fore limbs the structure of the feet recalls the golden moles rather than the true moles, the third and fourth toes being greatly enlarged at the expense of the others, and furnished with huge triangular claws of enormous digging power. In its pale, sandy-coloured hair, with a more or less golden tinge, the marsupial mole departs widely from our sable European friend; but it must be remembered that the difference in this respect is really not so great as it at first sight appears, seeing that cream-coloured varieties of the common mole are far from rare. In the Australian form the pale coloration is doubtless adapted to harmonize with the natural surroundings of its native desert, since it has been ascertained that the creature makes its appearance from time to time above ground. That the resemblance of the marsupial to the golden mole in the structure of

* It should be mentioned that by the term "burrowing" is here meant the construction of tunnels, and not a mere dwelling hole.

the fore-paws is a purely adaptive one, there can be no reasonable doubt; but whether the identical structural conformation of the molar teeth of the two animals indicates any real genetic affinity, or is merely inherited from an old ancestral type which may have been common to many groups, is far less easy to answer.

The marsupial mole, or ur-quamata, as it is termed by the aborigines, inhabits a very limited area lying about a thousand miles to the interior of Adelaide; and even there appears to be of extreme rarity. According to observations supplied to its describer, Dr. E. C. Stirling, the creature is generally found buried in the sand under tussocks of the so-called porcupine-grass (*Triodia*), and its food appears to consist of insects and larvæ. The animals appear only to move about during warm, moist weather; and as they are extremely susceptible to cold, it is probable that they lie in a more or less torpid condition during the winter months, when the surface of the ground is often white with frost. When on the move, the marsupial mole is said to enter the sand obliquely, and to travel for a few feet or yards beneath the surface, when it emerges, and after traversing a short distance above ground, once more descends. As it seldom tunnels at a depth of more than two or three inches below the surface, its course may often be detected by a slight cracking or movement of the surface as the tunnel proceeds. Both in this respect, and in the nature of its food, the ur-quamata therefore exhibits a further analogy with the golden mole. In burrowing, the leathery shield of the head is said to be brought into play as a borer in the soft sand.

As regards the advantages obtained by the mammals which have taken to a burrowing subterranean existence, it will be manifest that these are twofold. In the first place the creatures are secure from all foes, except those which, like the weasel and the snake, are able to follow them into their underground labyrinths; while, secondly, they tap a food-supply (whether animal or vegetable) which is inaccessible to most other animals. In the case of the mole at least, whose habitations are generally made in comparatively hard ground, the life must be an incessant round of labour; and to our thinking, at any rate, the existence of all these burrowing creatures must be so dull and monotonous as to leave no question as to whether it is worth living.

STELLAR SPECTRA AND STELLAR VELOCITIES.

By MISS A. M. CLERKE, *Authoress of "The System of the Stars" and "A Popular History of Astronomy during the Nineteenth Century," &c., &c.*

THE first spectroscopic review of the heavens, begun by Father Secchi at Rome in 1863, showed pretty clearly that the geometrical and physical relations of the stars are, to some extent, interdependent;* but the establishment of any general connection of the sort was only rendered possible by the publication of the *Draper Catalogue*. Not that the data provided in this repertory—valuable and ample though it be—are well enough assured to serve as the basis of other than preliminary conclusions. For the method by which they were obtained might be called without disparagement a rough-and-ready one; it was applied too extensively to be applied with discrimination. The stars had to be taken in batches as they came, with an unvarying exposure of five minutes, which was necessarily too long for some, and too short for others. The results should, then, be accepted most thankfully, and with full recognition of the energy, ingenuity, and resourcefulness employed in procuring them; but they should be accepted for what they are worth, and no more.

Again, the absence of settled criteria of classification gives rise to uneasy reflections. It is impossible not to feel some distrust of a system which recognizes no spectroscopic distinction between Capella and Rigel, both being comprised within the sub-class F; and indeed most of the stars designated in the *Draper Catalogue* as of the "Capellan" variety—sub-classes F and G—rank visually, according to Vogel, as of the Sirian type. How then, we cannot but ask ourselves, are differences so numerous and so glaring to be reconciled? To what court of appeal can we turn when eye and camera disagree? Decisions, moreover, presuppose definitions; and no agreement has yet been come to as to what constitutes the essential distinction between a first and a second type star. Perhaps the best available resides in the relative strength of the K-line; and as it lies in the faint violet region of the spectrum, its adoption would devolve the task of their discrimination upon photography. Thus the *Draper Catalogue*, in the construction of which this test has been carefully, though not exclusively, regarded, may turn out to be the best extant authority in the matter. The ratification of its data would be the more welcome as it would tend to fortify the important conclusions drawn from their discussion, some of which have been adverted to in the last number of KNOWLEDGE.

The most fundamental of these relates to the proper motions of the different orders of stars. Members of the solar class, whether of the Capellan or the Arcturian species, traverse the sphere much more rapidly than "white stars" resembling either Vega or Rigel. This seems to be a particularly solid fact. The chances are small that it will be overthrown by the progress of research. It is, then, of great interest to investigate its true meaning. What are we to understand by it? Are the less mobile stars, on the average, more distant, or are they animated by a lower real speed? If proper motion may be taken to be in any way a test of remoteness, the former alternative must be adopted; yet, as Mr. Ranyard truly remarks, "the assumption is by no means self-evident that all types of stars are moving with the same average velocity." Certainly not. The proposition requires to be proved; and if the evidence alleged in its support be inconclusive, all deductions regarding spectral distribution, in which mean proper motion is accepted as a measure of mean distance, must be accounted vitiated by a fundamental uncertainty. It seemed, then, worth while to recur to the subject for the purpose of enabling the readers of KNOWLEDGE to judge for themselves how far Prof. Kapteyn had succeeded in proving a general equality in actual physical speed between the constituents of the two chief stellar orders.

The principle of the inquiry was explained in the April number of KNOWLEDGE. It is that the component of stellar motion directed along a great circle passing through the sun's apex affords, since it is of perspective origin, a safe criterion of the distance from the advancing solar system of the group of stars to which it belongs. Either the remaining portion of their apparent displacements, on the other hand, being that directed across the line of the sun's way (designated τ), or the sum total of their movements (μ), affords an index to their genuine and original rate of transport. Evidently, then, when the perspective element and the original element in the proper motions of two

* Report, British Association, 1868, p. 169.

collections of stars bear somewhat about the same proportion one to the other, it is all but certain that the members of those two collections travel through space with approximately equal average velocities. This test has been applied by Prof. Kapteyn to several groups of Sirian and solar stars, variously selected and discussed, with the result of eliciting no systematic difference between their parallactic and their real displacements. That is to say, the small differences that emerged were alternately in opposite senses. Thus, he derived a mean angular value of 0·196″ for the sun's yearly translation (q) as viewed at right angles from 94 first-type stars common to Stumpe's list of proper motions and the *Draper Catalogue*; while 325 similarly selected second-type stars gave, for the same amount of mean total proper motion (μ), a value of $q=0·166''$. Taken singly, and interpreted strictly, this result would of course imply that the solar stars were, on the whole, more distant, consequently swifter-moving bodies, in the proportion of 196 to 166, than the Sirian stars compared with them. And a similar investigation of 189 Auwers-Bradley stars, with proper motions between 0·08″ and 0·09″, brought out a difference of the same character. But a more extensive and more searching inquiry suggested an opposite inference. Here the more stringent method was adopted of comparing the perspective element of proper motion, not with the total movement, but with the exclusively original element directed across the line drawn from each star to the sun's apex; and the stars considered were 230 solar and 338 Sirian, contained both in Auwers's and in Pickering's catalogues. The upshot was to make the Sirian stars this time appear further off and quicker, in the ratio of 37 to 31. It seems, then, difficult to contest, in the present state of knowledge, Prof. Kapteyn's conclusion that stellar rates of travel are independent of spectral distinctions.

CATERPILLARS' DWELLINGS.—II.

By E. A. BUTLER.

(*Continued from page* 63.)

THE solitary caterpillar, as might be anticipated from the nature of the case, greatly excels the gregarious one in ingenuity. The two great problems of its life are, as usual, the safety of its person amidst the dangers with which the outer world teems, and the assurance of a sufficiency of daily food. Having, in order to secure these ends, to rely entirely upon its own individual exertions, unaided either by parent or companion, and being moreover, so far as British species are concerned, a small and naturally defenceless creature, it endeavours to combine the solution of the two problems by a single device, either constructing its abode in the immediate neighbourhood of its food, or in a truly marvellous way making what is in reality an edible dwelling. In either case it becomes a little hermit, cut off from the world at large, and merely, like Prospero, "master of a full poor cell." In carrying out these designs, one or other of three methods is usually adopted, and these we may roughly distinguish as the method of the "tunnel," the method of the "enclosure" or "coil," and the method of the "portable case." Not that these constitute alternative plans, either of which may be adopted by each species as inclination directs or circumstances demand. On the contrary, each species has its own peculiar method of procedure, which it invariably adopts, thus exhibiting that uniformity of inherited habit to which the name instinct is applied.

The tunnel makers construct a silken tube or run in the midst of their food, within which the proprietor can rest secure from attack, and be at the same time within easy reach of supplies. Amongst the heads of umbelliferous flowers, we sometimes see silken tunnels of this kind, open at both ends, and running between the stalks of the different components of the umbel, other threads acting as cables for mooring the structure, and drawing the flower head together. Several of the smaller species of moths, especially amongst the Tineæ, adopt some such plan as this. Considering the immense number of insects of all orders that visit the flowers of the Umbelliferæ, one can see that these web-and-tunnel-forming caterpillars are much freer from disturbance than they would be if they fed in the open. There may be scores of little creatures of one kind and another crawling about overhead, ransacking the expanded head of flowers, but the caterpillar in its silken home, though close beneath them, is safe from molestation, enjoying a sort of privacy in public. Similarly, the caterpillars of the meal and tabby moths form silken galleries amongst the flour and chaff on which they feed; and so also do some of the clothes moths, the silk in this case being largely mixed with particles of the woollen fabric which they are doing their best to ruin.

Other excellent illustrations of gallery-making are to be found in the honey-comb moths, the chief of which (*Galleria cerella*) is so different in the male and female that Linné made two species out of it. The moths enter beehives in the evening, when the bees are resting, and lay their eggs on the combs. The caterpillar is a pale whitish creature, which feeds on the wax of which the combs are made, and as such depredations would of course be resented by the bees, some thoroughly reliable sting-proof shelter becomes necessary if the marauders are to carry out their enterprises successfully. Hence there is, in this case again, a very good reason for the construction of the silken tube, and the caterpillar, apparently conscious of the risk it would run if exposed, takes good care to spin its tube as far as it travels, and never to thrust out more than just the end of its body, that part being defended by a hard, thick skin, while the rest is soft and unprotected.

In this connection we may briefly notice those caterpillars that excavate minute tunnels or mines between the upper and under skins of leaves. Here the tunnel consists simply of the narrow, linear, zigzag space left by the insect as it devours the soft cellular parts of the leaf that lie between the two surfaces. The greenness of the leaf is not due to any colour in its outer skin, which is almost colourless and transparent, as may be proved by tearing a piece of it off. The green part is contained solely in the cellular tissue that constitutes the central layers of the leaf, and therefore when these are removed, a clear, transparent, or whitish track is left, which, however, usually shows a dark streak down its centre, consisting of the line of excrement left by the caterpillar as it progresses along its life-long course. Thus we often see the leaves of different trees, shrubs, and her-

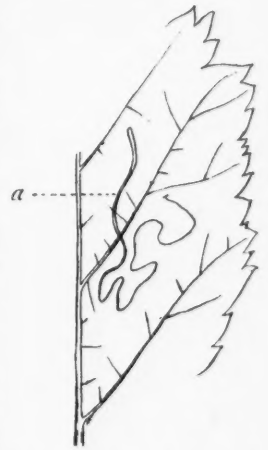

FIG. 4.—Portion of Nut leaf, showing *(a)* mine of a small Caterpillar (*Nepticula microtheriella*).

baceous plants such as buttercups, marked with curious zigzag lines of most fantastic shapes, very fine at the commencement and increasing in breadth till they abruptly terminate in a club-shaped end (Fig. 4) in the centre of which perhaps a little dark spot and swelling may be seen marking the position of the caterpillar itself. Sometimes, instead of a zigzag line, there is merely a discoloured irregular blotch; sometimes, again, the line follows the outline of the leaf, coasting, as it were, along the various indentations on its margin. But whatever be the precise character of the markings, they are always evidence of the presence, either at the time or shortly before, of a leaf-mining insect of some sort or other. Of course it is only very minute species that can subsist in this way; but almost all the smallest of the Tineæ, amounting to hundreds of species in Britain alone, are habitually leaf-miners. It must not, however, be supposed that all such mines in leaves are caused by the caterpillars of Lepidoptera; other kinds of insects have similar habits, especially some of the smaller flies, a well-known mine in primrose leaves, for example, being caused in this way.

Each mine is the register of the entire larval history of one single insect; its intricacies and windings represent the episodes of the tiny career, and its extent gives an accurate measure of the total amount of food consumed by the insect from its birth till its pupahood, and in fact, one might probably say, till its death, for as a chrysalis it takes no food, and, as a rule, no doubt the same is true of its brief adult life. In each of these mines, then, we have a record, indelible as long as the leaf on which it is traced endures, of the exact amount of work done in the way of the destruction of vegetable produce by a single insect during the whole of its career; and yet, so minute are they, that sometimes half a score of them will be found on a single leaf of no more than moderate dimensions, the great mass of it even then remaining untouched, so that it only seems as if the leaf were adorned here and there with an elegant tracery of filigree work. The little moths whose larvæ are the excavators of these mines are oftentimes some of the gems of the insect world, and were they only larger, would attract universal attention by their splendour. Snowy white or jet black wings, with bars, streaks, or spots of burnished gold or silver, purple or orange, adorn many of them, but they are often too minute for their beauty to be fully recognized and appreciated without the help of a lens.

The second method of home construction is that of folding the edges of a leaf upon one another so as to make an enclosure, or else rolling it up into a coil. There is a large group of small moths that, from the frequency of this habit amongst them are called Tortrices, *i.e.*, "twisters"; they are also known as "leaf-rollers." There is a general similarity of style and shape about them that makes it usually an easy matter to distinguish them from members of other groups. When resting with wings closed, they generally appear as distinctly triangular little moths, with almost straight edges to the fore-wings after a great bend at the shoulder; but sometimes the outline is more like that of a bell (Fig. 5). Many of them are excessively abundant, not only in woods and hedges, but also in gardens. One of the commonest and best known is the lovely little emerald green moth (*Tortrix viridana*), which is a very familiar object in woods in June. It infests a number of trees, but especially the oak and hornbeam, and from its association with the former has sprung its popular name of "green oak moth" (Fig. 6). The caterpillars appear in May, while the oak leaves are young and tender. The operation of leaf-rolling is a truly remarkable process, when we consider the size and helplessness of the insect. Taking advantage of some natural curvature in the leaf, the young caterpillar plants itself at the spot, and bending its head from side to side, runs a few short threads from its spinneret tightly across from the extreme point that can be reached on the one side to a corresponding distance on the other—then placing itself at the centre of the little band so constructed, and thereby slightly pressing it down and therefore bending the leaf still more, it runs another set of threads in a slightly different direction, but crossing the others at the centre. So it proceeds till it has made a strong band, which fixes the edge of the leaf in the somewhat curved position into which it has been bent. By similar operations at intervals along the same line, a long roll is produced across the leaf; other little bands of silk, added to the outer surface of this in the same way, cause it to be rolled over still further, thus commencing a second turn of the coil, and so on till ultimately as much as half the leaf may become rolled up. The direction of rolling is not always the same, even with the same species; sometimes it is longitudinal to the leaf (Fig. 7), sometimes transverse, or again diagonally placed. It seems not improbable that the bands of thread, after they are run across, contract somewhat in length so as to increase the curvature of the leaf, by pulling the edges together; otherwise it is difficult to understand whence sufficient power could be obtained by so small and weak a caterpillar, working with a gum which is in a semi-fluid condition as it issues from the spinneret, to overcome the rigidity of so stiff a leaf as that of the oak tree, and coil it up as deftly as human fingers could do it. It is said that if the caterpillar, in the course of coiling the leaf, comes across a vein which is too tough and stubborn to bend as required, it weakens its resistance by biting it partly through, thus manifesting a marvellous degree of intelligence.

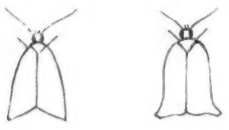

Fig. 5.—Outline of moths of leaf-rolling Caterpillars (*Tortrices*), in position of rest.

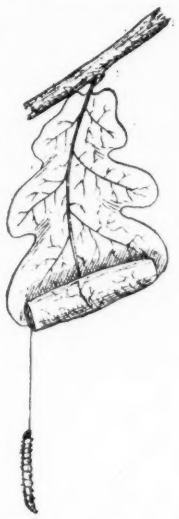

Fig. 6.—Caterpillar of Green Oak Moth, hanging from coiled oak leaf.

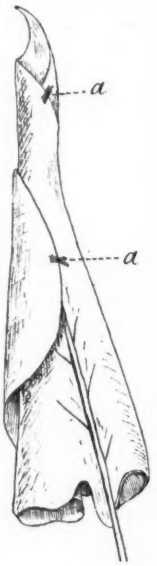

Fig. 7.—Lilac leaf rolled by Caterpillar. *a*. Silk fastenings.

The coil so made is open at each end, and the caterpillar then places itself inside and remains there unless dislodged, feeding upon those surfaces of the leaf which line the coil, carefully avoiding, however, causing any damage to the last turn of the coil, which would of course bring about the opening up and destruction of its snug little domicile. When it has devoured so much of its walls as is available and safe, it gives another turn or two to the coil, thus bringing what

was previously the last turn into an internal position where it may be eaten with impunity. In this sort of life some two or three weeks are spent. If the insect is disturbed in any way, as by jarring the branch, or meddling with the leaf, it usually prefers not to rely on the concealment afforded by its retreat, but to rush out into the open. Wriggling through the outer end of the tunnel, it drops towards the ground, at the same time running out a thread, at the end of which it hangs suspended in mid-air some six or seven feet down. By this thread it can regain its cell when the danger is past. No doubt they often escape from birds in this way, as the thread is almost invisible, and therefore the insect, by suddenly dropping out of the tube at the opposite end to that where the enemy is posted, passes instantaneously out of the range of its hunter's vision and saves its life.

In due time it changes to a reddish-brown chrysalis inside its leafy coil. This, too, is very active, wriggling violently if at all disturbed. The segments of the abdomen of the chrysalis are each furnished with two rows of little hooks (Fig. 8), which are of great importance to the insect when it is ready to become a moth. When the critical moment has arrived the chrysalis works itself along by the help of the hooks to the open end of the tunnel, and thrusts the front half of its body through the aperture. Then the skin splits as usual in the exposed part, and the little moth drags itself out of its case, and prepares to spend the few remaining days of its life in the open air, sitting about on leaves, or fluttering round the bushes in an intermittent and sluggish way.

Fig. 8. — Body of chrysalis of Leaf Roller, showing hooks.

The green oak moth is sometimes so numerous as to be exceedingly destructive, quite stripping the trees of their first crop of leaves, but at the same time providing a glorious feast for the insectivorous birds which chatter around in exultant chorus, expressive no doubt of supreme delight. Such was the case last year, when, in a certain wood near London, at the end of May, every oak tree over a particular area was black and bare at a time when all the trees of other kinds around were brilliant with the fresh green spring foliage. If the trees were shaken, down fell showers of caterpillars, some precipitated to the earth by the violence of the jerk, others hanging from threads and dangling about in mid-air. A little later in the season, similar shaking would bring down a shower of chrysalids. The leaves of these trees were so completely destroyed that, had it not been for their dried and withered fragments still held together by the little silken cords, one would have imagined that no leaves had yet been produced. Fortunately, they were replaced by a second crop after their destroyers had passed beyond the stage of leaf eating. Many others of the Tortrices carry out their designs in essentially the same way, only varying the details. Some, for example, simply double the two halves of a leaf upon one another; others fasten several leaves together and take up their abode in the midst; others, again, make an incision into a leaf and then turn down or roll up the flap so loosened. In gardens, rose trees are very liable to the attacks of several species, some of which, exceedingly handsome little orange-coloured moths, fold up the leaves, while others establish themselves within the young flower buds and devour them.

(*To be continued.*)

THE NUTHATCH.

By Harry F. Witherby.

THE nuthatch (*Sitta europæa*) is the only representative of the genus *Sitta* to be found in Great Britain.

It is tolerably abundant in England, especially in wooded districts, and it remains with us all the year round. It is not found either in Scotland or Ireland.

The nuthatch belongs to the same order, or family, of birds as the woodpecker genus, *i.e.*, the scansores, or climbers, and it is a very good type of that order.

The general colouring of the bird is bluish-grey on the back and upper side of the wings, and buff on the breast, shading to a bright chestnut on the under tail-coverts. The upper and under side of the bird thus produce a beautiful contrast in colour. The throat is silvery white. A black line of feathers, very similar to the "moustache" of the woodpecker, runs from the base of the mandible through the eye to the bird's shoulder.

In comparing the nuthatch with the genus *Picus*, or woodpeckers, a great difference in the respective form of each is noticeable, and especially in the shape and texture of the tail feathers. We have already seen that the woodpecker's tail feathers are long and pointed, and that being strong they are very useful to the bird when climbing, whilst the tail of the nuthatch, on the other hand, is short and square, and is composed of soft feathers, which could not be so used. The nuthatch is extremely agile in its movements, and a long tail would no doubt be an inconvenience to it, whereas its short tail never impedes it.

The lack of usefulness in the tail for climbing purposes is amply made up by the construction of the bird's foot. This has three toes pointing to the front and one behind, all of which are armed with strong, sharp claws, curved at the ends. The hind toe and claw are much longer and stouter than the others.

The bird is seldom seen upon the ground, but lives in the trees. With the help of the claws it is enabled to climb with the most extraordinary ease. The bird is remarkable for its agility, and is scarcely ever seen at rest, nor does it seem to be impeded by the law of gravity in the slightest degree when climbing, for it will descend the tree head foremost, a feat which no other bird of its tribe can perform. It creeps along the under side of a branch as frequently as on the upper side. The nuthatch does not climb with a jerky motion like our woodpeckers, but creeps, or rather runs, along as smoothly as a mouse.

The food of this bird is chiefly composed of insects, berries, acorns, and beech-mast, but it is also very fond of the kernels of hazel nuts, which it extracts from the shell in a very clever way. Having obtained a nut from a tree, or from some store hidden by the bird itself, it carries the treasure in the beak to some rough-barked tree hard by, such as an old oak or old birch, and then proceeds to fix the nut securely in a crevice of the bark. The bird then commences to hammer with its beak until it has made a hole in the shell large enough to extract the kernel. Occasionally the bird will place itself over the nut, and attack it head down, probably to give additional force to its blows. Should the nut be dislodged during the operation, the bird is so marvellously quick that it will invariably catch it in its beak before it reaches the ground. From this habit of breaking nuts, it has earned the name of nuthatch, which is probably derived from the French "hacher" to chop, hence our hatchet.

While clinging to the bark to deliver a blow, the bird is greatly supported on the hind part of the leg, which may,

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perhaps, be called the heel of the foot, upon which it throws most of its weight, just as the woodpecker throws its weight on the tail, when in a similar posture. When pecking very hard, the bird bends its head right back, and, as it strikes the tree, gives a flap with its wings in order to preserve its balance. If the bird cannot easily dislodge a piece of bark at which it is pecking, it will walk all round it, tapping it with its beak at every possible point, until the object is attained. The beak being broader than high at the base, and very hard, is well suited to give a strong blow.

The nesting habits of this bird are peculiar. It builds in a natural hole in a tree, not boring a hole for itself like the woodpeckers; but if the entrance to the cavity should be too large, or if there be any unevenness in it, the bird will plaster it round with mud to make the hole the required size, and it never seems to be satisfied until the hole is exactly round, and only just large enough for it to enter.

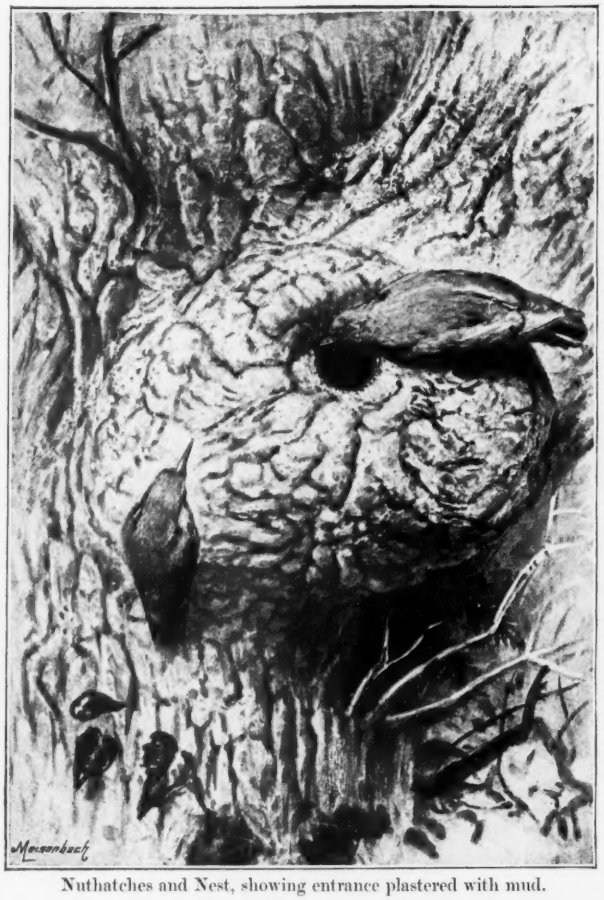
If the mud be examined, the marks of the bird's beak in the form of minute holes are seen all over it, showing with what care the work has been done.

In some parts of the country, in the New Forest for instance, the nuthatch is called the "mud-dabber," from this singular habit of "dabbing" mud round the entrance to its nest.

Nuthatches very often fight with tits of various kinds for the possession of a favourite hole for nesting purposes; and this may be the reason for its habit of making the entrance as small as possible, as a larger aperture would be less easily defended.

The nest itself is composed of moss and leaves, and very often chips of wood are introduced; one which I examined was entirely composed of small flakes of bark from a yew tree. These materials are all broken up into very small fragments, so that the leaves look as if they had been cut in pieces with a pair of scissors. They are carried into the hole apparently without any order, and no attempt is made to weave them together. Upon this nest the bird lays her eggs, which are usually five to seven in number. They are white, spotted over with reddish-brown, and can scarcely be distinguished from the eggs of the cole tit (*Parus ater*).

The eggs are usually laid in the middle of May. During the process of incubation, which lasts some fourteen days, the bird sits very close, and may be even looked at without causing her to leave the nest. A hole quite close to the road is very often chosen for the nest, and I have known one that was situated just over a seat that was in constant use. The bird hides the eggs in the nest before leaving it.



Nuthatches and Nest, showing entrance plastered with mud.

The nuthatch is not a good musician. It has no regular song, but utters several different call notes, the chief of which is very shrill and piercing, and when once heard will not easily be forgotten. It sounds like the syllable "twhit" repeated very quickly, usually four or six times in succession. It has also a note sounding like "twe-twhit," the last syllable being longer than the first, which is very short. Another note, not so often used, resembles the syllable "tyrrh," repeated quickly twice, and then a third time prolonged.

The flight of the nuthatch is undulating, but very rapid.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

THE η ARGÛS NEBULA.

To the Editor of KNOWLEDGE.

DEAR SIR,—In the very interesting paper comparing Sir John Herschel's drawing with Dr. Gill's photograph, in mentioning the trident-shaped structure, it says: "There seems to be no nebulosity corresponding with it in position on the photograph."

Is there not a faint nebulosity, corresponding to the drawing shown in the photograph, in row 10, columns 22 and 23, and lower part of row 11, column 23?

There appears to me a curve, as it were the "Swan's" head, with a star on either side of the line, between rows 10 and 11 in column 23, very similar to Sir John Herschel's drawing.

Yours truly,
VINCENT YARDLEY.
"Ravenscroft,"
Church Hill,
Hoddesdon, Herts.
April 19th, 1893.

[Mr. Yardley is, I think, correct, but if we assume that the structure he refers to was the one seen and drawn by Sir John Herschel, we must make one of three assumptions—either there has been a great change in the relative brightness of various parts of the nebula since 1837; or Sir John Herschel must have made serious errors in estimating or in representing the relative brightness of different parts of the nebula, and he must have seen with his great Herschelian reflector parts of the nebula which now, by reason of their faintness, are only just traceable in Dr. Gill's photograph, taken with an exposure of over twelve hours; or the brightness of this structure as seen with the eye must be greater than as shown in the photograph—for example, its light might be redder than that of the rest of the nebula.

By a careless mistake I referred to Herschel's great

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THE STAR CLUSTER, ω CENTAURI.

From a Photograph taken by Dr. GILL, at the Royal Observatory, Cape of Good Hope, on 25th May, 1892, with the Astro-Photo-telescope of 13 inches aperture, used for the International Survey of the Heavens.

Diameter of circular region shown in the Photograph, 22 minutes. Exposure, three hours and three minutes.

Direct Photo Engraving Company, 9, Barnsbury Park.

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telescope, in the last number, as a Newtonian reflector. It is of course well known that Herschel did not make use of a flat to throw the image to one side of the tube—this would have saved him a little light—but his speculum metal reflector must have behaved remarkably well, as compared with silver on glass reflectors, if it enabled him to see parts of a nebula which are barely traceable on a photograph, such as Dr. Gill's, taken with twelve hours' exposure.

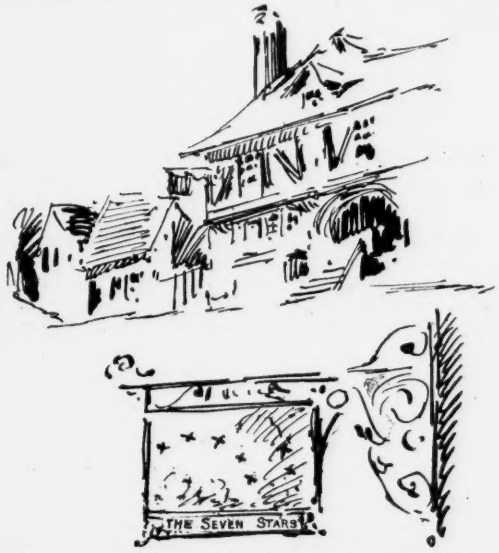
Some may say: If there are variable stars, why should there not be variable nebulæ? But I hesitate to assume too lightly that there is reliable evidence of simultaneous changes of brightness taking place over such vast regions as must be occupied by a structure as large as that shown in Sir John Herschel's drawing.—A. C. Ranyard.]

ASTRONOMY AND SHAKSPEARE.

To the Editor of Knowledge.

Dear Sir,—I enclose you a rough outline sketch of a very old roadside inn in Warwickshire, called the "Seven Stars of Gurnal." As this is only a few miles from the poet's birthplace, I have no doubt he may have often quaffed his ale beneath this very sign. Yours faithfully,

Hartlepool, March, 1893. H. Beck.



[Messrs. Jacob Larwood and John Camden Hotten, in their "History of Signboards," speak of the Seven Stars as a very common old sign, but does not the iron work of the sign drawn by Mr. Beck point to a later date than Shakspeare's? Messrs. Larwood and Hotten speak of the "Half Moon and Seven Stars" at Aston Clinton, near Tring, and the "Sun, Moon, and Seven Stars" at Blisworth, in Northampton. They say: "These seven stars have always been great favourites; they seem to be the same pleiad which is used as a masonic emblem—a circle of six stars with one in the centre—but to tell to ears profane what this emblem means, would be disclosing the sacred arcana." There was a printing-house with the sign of the seven stars in St. Paul's Churchyard, near to the great north door; but whether they were arranged masonically or Great Bear-wise, I do not know. Here in 1653, J. C. and Richard Moon printed "The first addresses to His Excellency the Lord General, &c., by John Spittlehouse, a late member of the army, and a servant of the Saints of the Most High God."—A. C. Ranyard.]

THE POLECAT IN CARDIGANSHIRE.

To the Editor of Knowledge.

Dear Sir,—In the "Science Notes" in the April number of Knowledge, you quote Mr. J. W. Salter as stating "that there is reason to believe that the polecat is by no means extinct in Cardiganshire." Having passed a good deal of time every year in that county during the last thirty-two years, I can corroborate Mr. Salter's assertion; the animal is very frequently met with. I have seen dozens of skins for sale in the shop of a tradesman in a small town in Cardiganshire—he makes a speciality of collecting them—and I believe the price paid for them is from 1s. to 1s. 6d. per skin, according to quality.

Yours faithfully,

New University Club, St. James's Street, S.W., April 17th, 1893. Thos. Herbert Maddy.

To the Editor of Knowledge.

Sir,—The numbers referred to in the "figure squares" problem on page 75 of your April number are the sums of the squares of the co-efficients in the expansion of $(x + y)^n$, the formula for which is $\frac{|2n}{|n\ |n}$

Yours faithfully,

Technical Schools, Plymouth, April 15th. J. J. Alexander.

[I have received more than one note pointing out that the general term of Mr. Staniforth's series is factorial $(2n)$, divided by the square of factorial n. This will be evident to Mr. Staniforth if he throws his series into the form—

First term ... $\frac{2}{1}$

Second term ... $\frac{2}{1} \times \frac{6}{2}$

Third term ... $\frac{2}{1} \times \frac{6}{2} \times \frac{10}{3}$

nth term... ... $\frac{2}{1} \times \frac{6}{2} \times \frac{10}{3} \times \frac{14}{4} \times \frac{18}{5} \ldots \times \frac{2(2n-1)}{n}$

Mr. T. B. Sprague has, in a recent paper published in the "Transactions of the Royal Society of Edinburgh," shown that such figure squares may be used for "A New Algebra," by means of which permutations can be transformed in a variety of ways and their properties investigated.—A. C. R.]

THE IGNIS FATUUS.

To the Editor of Knowledge.

Dear Sir,—Mr. Marshall Fisher, of Ely, has been so good as to forward me some extracts of a work on New Zealand, published in 1855, by the Rev. Richard Taylor, M.A., F.G.S., formerly curate of Coveney-cum-Manea, in the Isle of Ely.

Mr. Taylor encamped on a rainy night in a forest near the Bay of Islands, when the natives who accompanied him erected a hut, and covered it in with palm leaves, so as to make it water-tight. Fires were kindled and everything made comfortable. No sooner, however, had the men fallen asleep, and the fires began to die away, than a light was observed, like the moon shining through a chink. There was no moon, and the night was very dark. On a closer examination the object appeared as a globe of pale light attached to the point of a palm leaf which hung from the roof. Another ball of light was now seen, attached to the wet sleeve of a shirt hung up to dry. "The air appeared to be charged with these luminous vapours, for while regarding the two in the shed a series of them floated past at an elevation of about a yard from the ground." These and similar phenomena, which are evidently electrical, the author endeavours to trace to the remains of the highly resinous *Kauri* pines which abound in the place.

Should the reader object that these electrical effects would not be likely to occur on a rainy night, he may be reminded that every shower is an electrical phenomenon, and that the rain itself is sometimes luminous. Thus, an officer of the Algerian army states that during a storm on the 25th of September, 1840, the raindrops that fell on the beards and moustachios of the men were luminous.

The author also refers to a luminous appearance which he witnessed one night in the Isle of Ely. It advanced rapidly, and distinctly touched his cheek, when he perceived a sensible glow, but his breath seemed to make it bound away again. This appears to have been a case of marsh gas, but the author thinks that it—namely, the ignis fatuus—is simply "a luminous air, a phosphoric light, arising from the oily particles of decomposed aquatic plants . . . or from the gas of the many resinous pine trees which once grew there, and whose remains still lie buried in the peat."

But the most singular case remains to be told. A brig off New Zealand, having been visited by some electrical brush discharges, the author accounts for them in the following manner:—"These marine lights most probably arise from the decomposed remains of fish, raised to the surface by the violent motion of the water in storms."

Yours faithfully,

C. Tomlinson.

WHAT IS A STAR CLUSTER?

By A. C. Ranyard.

IT is hardly possible to conceive that a star cluster such as that shown in our plate can form a permanent system, in which the stars move on from age to age without collision. The facts that we are already in possession of, with regard to the motion of binary stars, seem to render it very probable that the reign of gravity extends to stellar distances, though it must be admitted that we have no indisputable evidence that gravity acts across the interstellar spaces, or even that the apparently elliptic paths, which observation shows that the components of a binary star describe about one another, are swept out under the action of a force varying as the inverse square of the distance from their common centre of gravity. But in view of the facts with which we are familiar in our solar system, this is the simplest assumption to make, and the observed motions of such binary systems are what gravitation easily accounts for.

More that fifty years ago Sir John Herschel saw the extreme difficulty of imagining the "conditions of conservation of such a system as that of ω Centauri, or 47

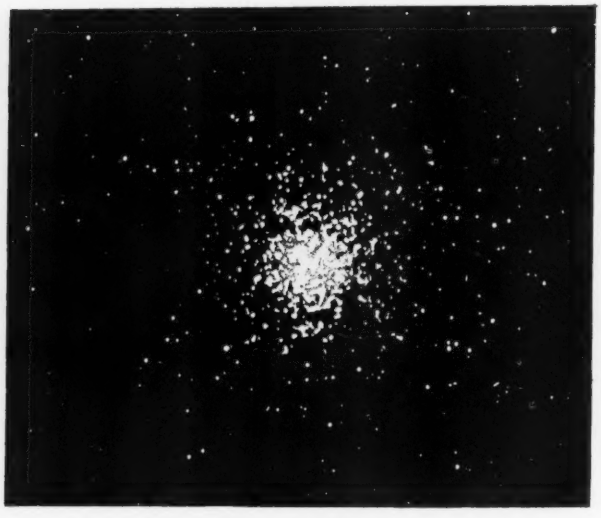


Fig. 1.—Untouched block made by a photographic process from a photograph of the Great Cluster in Hercules, taken by the Brothers Henry, 23rd June, 1886.

Fig. 2.—Untouched block made by a photographic process from a photograph of the Great Cluster in Hercules, taken with the 36-in. refractor of the Lick Observatory, 24th September, 1892.

Toucani, &c., without admitting repulsive forces on the one hand, or an interposed medium on the other to keep the stars asunder."* But if we put on one side assumptions as to repulsive forces, and endeavour to consider the changes which will probably take place under the action of attractive forces such as we are familiar with in our region of space, we shall be forced to admit that a spherical star cluster cannot be a permanent system, and that the individual stars of the cluster can only escape collisions for a limited period of time. Next let us proceed to consider the results that will probably follow such cataclasms. At every such collision, motion of translation will be turned into heat, and a change in the physical condition of the colliding bodies, or a part of them, may be expected to follow.

Prof. George Darwin has pointed out that if two solid bodies were to collide with planetary velocities, there would be a very rapid development of gas between them at the region of contact, which would cause them to rebound from one another almost as if they were perfectly elastic bodies. If the moving bodies were liquid or gaseous, no doubt a similar evolution of heat would take place at the region of contact with an explosive development or expansion of gas, that would drive the masses away from one another, causing them to rebound with velocities almost equivalent to their velocities of approach; and it seems probable that within a short period after such a collision, the gaseous matter evolved at the region of contact would be distributed in space between the rebounding bodies.

Now let us pass to what is actually observed. It has long been remarked that globular clusters frequently present a partially radiated appearance in their outer parts,

* "Cape Observations," p. 139.

and that streams of stars appear to spring from them and to curve away into space. It is difficult to conceive of a stream of stars that is not flowing. The alignment of a

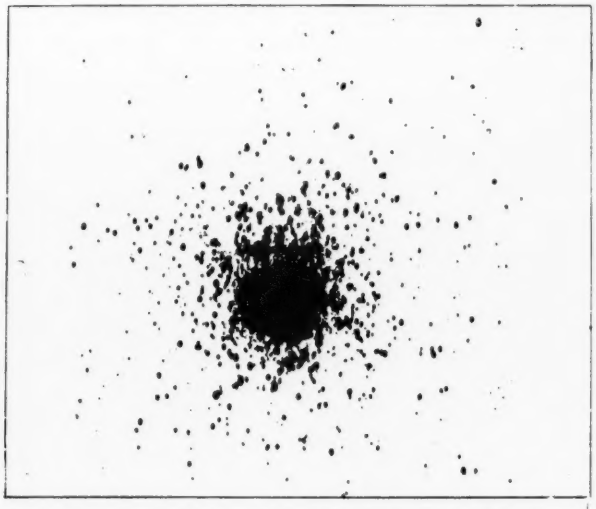


FIG. 3.—Untouched block made from the photograph of the Hercules Cluster, taken at the Lick Observatory, which is reproduced in Fig. 2, but black represents white, and the etching is not carried as far as in Fig. 2.

group of stars suggests their motion with different velocities from a common origin, and that they will be found to be associated with a stream of matter. In the Pleiades cluster we have actual photographic evidence of a narrow nebulous stream of matter linking together an alignment of six stars; and Prof. E. C. Pickering has photographed, in the Orion region, a faint nebulous band of light which actually links together a line or stream of sixteen faint stars,* and many other instances of stars distributed along streams or bands of nebulous matter might be quoted.

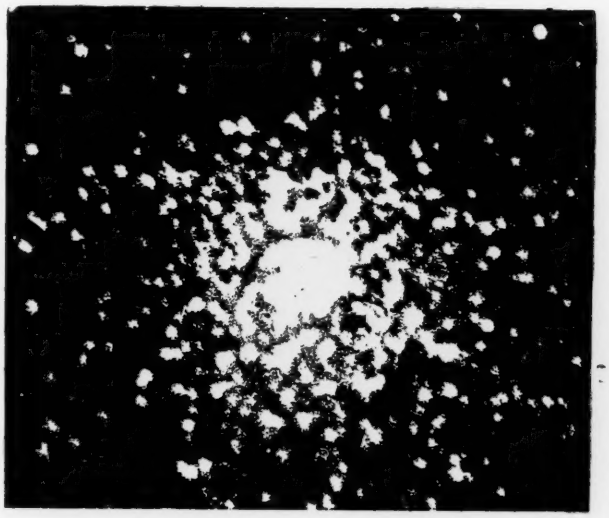


FIG. 4.—Untouched block made from a photograph of the Great Cluster in Hercules, taken by Dr. Isaac Roberts on 22nd May, 1887.

In a space closely crowded with stars like the central region of a star cluster we should expect frequent collisions to take place, and, as the result of such collisions, we should expect to find streams of nebulous matter associated with alignments of stars radiating from the central mass; in fact, we do find that nearly all star clusters show traces of nebulosity, and that the brighter regions of most of the great nebulæ coincide in position with clusters of stars which the nebulous matter evidently surrounds. Nebulæ and star clusters are divided by no hard and fast line. The larger nebulæ may be described as groups of stars surrounded by bright nebulosity, and star clusters may be defined as groups of stars surrounded by a faint nebulosity.

I am indebted to Dr. Gill for the interesting photograph of the ω Centauri cluster; a general nebulosity will be recognized extending through it, especially in the region where the stars are most closely packed, and it will be seen that the nebulous background is interrupted here and there by narrow dark channels—similar to those we have recognized in many nebulæ, and in several nebulous regions of the Milky Way.

The blocks are made from several photographs of the great cluster in Hercules—which have all been reduced by means of photography to the same scale—and have been

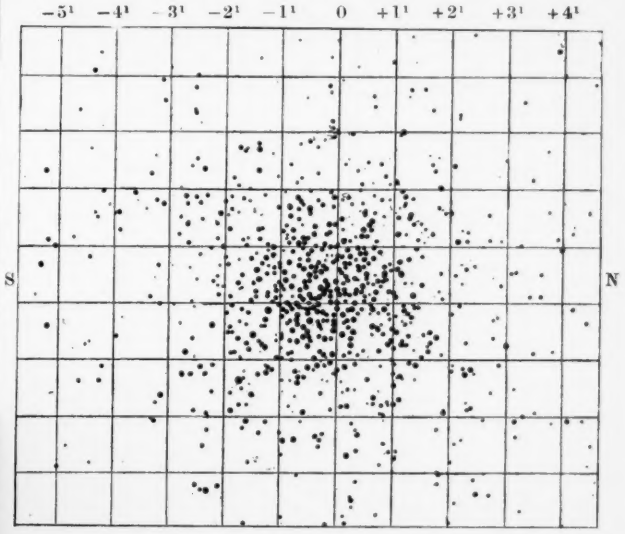


FIG. 5.—Copy of a chart of the Great Cluster in Hercules, made by Dr. J. Scheiner, of the Astro-Physical Observatory at Potsdam, in 1891.

oriented with the same point uppermost, and turned over where they were reversed right and left. The correspondence between Dr. Isaac Roberts' photograph and those taken by the Brothers Henry and at the Lick Observatory will not at first be evident, because the exposure of Dr. Roberts' photograph is considerably greater than the exposure of the photographs taken at Paris and at the Lick Observatory, and consequently the nebulous area shown is larger, and all the stars in Dr. Roberts' photograph are represented by larger patches than in the Paris and Lick photographs. But making these allowances, it will be seen that the photographs correspond, star for star, and that most of the stars shown in Dr. Scheiner's chart can be identified on the photographs.

In the Paris and Lick photographs very curious projecting structures will be seen extending from the central mass of stars and nebulosity. More than one of them has the branching character which reminds one of the forms taken by the streams of heated gas which rush upward from the solar photosphere, but in the case of this

* See "Annals of Harvard College Observatory," Vol. XXVII., p. 155.

XUM

cluster the prominence forms do not appear to be wholly gaseous or nebulous, they are marked out by a series of stellar points.

The scale of the annexed block is not sufficiently large to show the details which are visible in the Lick and Henry photographs, and I will endeavour on some future occasion to give the readers of Knowledge a tint block showing the details of this remarkable structure on a larger scale. To my mind the form of the structure indicates the existence of a stream of matter on a colossal scale rushing outward from the central region of the cluster, and the broadened summit of the structure seems to me to indicate the passage of the stream through a resisting medium, the density of which is not negligible compared with the density of the out-rushing stream. This would seem to indicate that the density of the stars associated with the out-rushing stream cannot be very considerable, or their motion would not be retarded by the resistance of a nebulous medium. Any assumption involving the existence of an extensive resisting medium, with a density equal to a ten thousand millionth part of the density of our own atmosphere at the sea level, lands us in difficulties similar to those which we pointed out in discussing the density of the Orion nebula,* that is, the mass of the nebula would be so great that it would become recognizable to us by reason of the very rapid proper motions of stars in its neighbourhood, whatever were the distance of the nebula. In fact, the greater the distance of the nebula (its angular diameter remaining the same), the greater would be the attracting mass of the nebula, and the apparent motion of stars in its neighbourhood would remain unchanged.

Fig. 6.—The Prominence-like Structure.

Our own sun—if it were expanded so as to fill a sphere with a diameter equal to the diameter of the orbit of Neptune—would have its average density reduced more than two hundred thousand million times; but since the average density of the sun is 1·444 times that of water, the density of the sun, when expanded so as to fill the orbit of Neptune, would still be considerably greater than a ten thousand millionth of the density of atmospheric air at the sea level. It may easily be shown that a star, similar in density and magnitude to our sun as it now is, would lose an inappreciable fraction† of its velocity if it plunged diametrically through the matter of the solar system when heated up so as uniformly to fill such a Neptunian sphere, even if we assume that in passing through such a Neptunian mass the star cut a tunnel of ten times its own diameter, and gave to all the matter within the tunnel a velocity similar to its own initial velocity on entering. It seems to me, therefore, that we may conclude that the stellar masses which lie along the gigantic structure shown in Fig. 6 must have very small masses compared with our sun, for their density must be very small indeed compared with the density of our sun. In fact, they must be quite a different type of body from the stars we know, if their density is comparable with the average density of the resisting medium which fills the interspaces between the stars of such a cluster.

Science Notes.

An enormous meteorite, weighing nearly one ton, from Western Australia, has been received by Mr. J. R. Gregory, of Charlotte Street, Fitzroy Square. It is 4 feet 2 inches long by 2 feet 3 inches wide, and 2 feet 6 inches thick.

From observations of the minor planet Victoria, made at twenty-one meridian observatories in 1889, Dr. Gill has obtained the value 8·809″ for the solar parallax, with a probable error of ± 0·0066″. An incidental result brought out by the discussion of the observations is that Leverrier's determination of the perturbation of the moon's action on the earth is too high. If this be so, then the value generally accepted for the mass of the moon will have to be decreased by about one per cent.

The *Astronomical Journal*, No. 292, contains some notes by Prof. Asaph Hall on the masses of Mars, Saturn, Uranus, and Neptune, determined by observations of their satellites. The definitive values obtained are as follows:—

Mass of Mars	-	$\frac{1}{3,104,700}$	of the sun's mass.
Mass of Saturn	-	$\frac{1}{3486·5}$	,, ,,
Mass of Uranus	-	$\frac{1}{22,765}$	,, ,,
Mass of Neptune	-	$\frac{1}{19,149}$	,, ,,

There is still a good deal of speculation with regard to the substance which Prof. Dewar lately exhibited as solid air. The frozen mass might contain both solid oxygen and solid nitrogen, or solid nitrogen alone with liquid oxygen interspersed. Substances which possess the property of retaining liquids in an apparently solid form—like gelatine—are known as "colloids," but it would be hazardous at present to assert that nitrogen belongs to this class. Air, however, becomes solid at a temperature and pressure at which pure oxygen retains its gaseous state.

In a review of "The Old and New Astronomy," in the current number of the *Edinburgh Review*, the writer, whilst admitting the existence of "singular vacuities" and "star-fenced lanes" in the Milky Way, advocates the theory that "such vacancies are undoubtedly what they seem; they are obscure simply because they are destitute of stars. They are negative entities." Though the evidence for the actual existence of dark structures is not accepted by the reviewer, he freely admits the actual existence of bright tree-like forms springing from dark areas. It is remarkable how differently various minds estimate evidence from probability, which cannot conveniently be expressed in numbers.

Two Akka girls, representatives of the pigmy race of Africa, who were rescued from Arab captors by Dr. Stuhlmann and his companions, have been brought to Europe, and will remain in Germany for some months. In the summer they will be taken back to Africa, where they will be placed in some mission house, or otherwise provided for. Though probably from seventeen to twenty years of age, they are only as tall as an ordinary boy of eight. According to a correspondent of the *Daily News*, who saw them at Naples, their behaviour is "infantile, wild, and shy, but without timidity . . . . They showed neither wonder nor admiration of the people and things around them."

The London Geological Field Class commences its summer afternoon excursions this year on the 29th April. The excursions are planned by Prof. H. G. Seeley, who accompanies the class every Saturday afternoon, whether the weather is wet or fine, from the end of April till the end of July. The class visits classical geological sections and places of interest in the neighbourhood of London. The railway journey generally occupies from half an hour to an hour, and the distance walked is from three to six miles. The class is open to ladies and gentlemen, and the fee for the twelve excursions is one guinea.

* "Old and New Astronomy," p. 793.

† Less than a three hundred thousandth part.

In future *The Observatory* will be conducted by Mr. T. Lewis and Mr. H. P. Hollis, both of the Royal Observatory, Greenwich. Mr. H. H. Turner remarks, in an editorial notice, that Dr. Common and himself have withdrawn from the editorship because the many calls upon their time prevent their giving the attention to the magazine which alone could ensure its being a complete record of current astronomical events.

Lord Rayleigh, in lecturing at the Royal Institution on interference bands, exhibited as an illustration of wave action a "bird-call," whose pitch was so high as to be inaudible. The concentration of the air waves, however, on to a sensitive flame, by means of a screen, caused the flame to roar in a remarkable manner.

It is commonly known that the simple relation between planetary distances, termed Bode's law, was first discovered by J. D. Titius, of Wittenburg. Mr. W. T. Lynn points out in *The Observatory* that Titius seems to have suggested that the gap between the orbits of Mars and Jupiter would be filled by the discovery of new satellites. Bode, on the other hand, expressed the view that the gap pointed to the existence of a new planet, and when Ceres was discovered in 1801 he claimed the fulfilment of his conjecture. This probably explains why the geometrical progression of planetary distances is known as the law of Bode instead of the law of Titius.

Some experiments on the resistance of ice have recently been made in France. From the results it appears that a thickness of rather more than one and a half inches is required to bear the weight of a man on the march; a thickness of three and a half inches is sufficient to permit the safe transit of detachments of infantry in files; and with about four and three-quarter inches, guns may be transported across the ice. M. Forel points out in the *Revue Scientifique* that these estimates apply only to young ice. Ice which has been exposed to alternations of temperature for a few weeks loses much of its tenacity and breaks far more readily than younger formations.

At the Royal Society, on March 23rd, Lord Rayleigh communicated a paper on "The Densities of the Principal Gases." He has determined the absolute densities of air, oxygen, and nitrogen, by comparing the weight of a volume of each of these gases with that of an equal bulk of water. The results obtained, reduced to standard conditions, are: Air, 0·00129327; oxygen, 0·00142952; nitrogen, 0·00125718. Taking the ratio of the densities of oxygen and hydrogen as 15·882, the absolute density of the latter gas is found to be 0·00009009. If the density of air is taken as unity, the density of oxygen is found to be 1·10535, of nitrogen 0·97209, and of hydrogen 0·06960.

The following are among the lecture arrangements at the Royal Institution after Easter: Mr. John Macdonell, three lectures on symbolism in ceremonies, customs, and art; Prof. Dewar, five lectures on the atmosphere; Dr. R. Bowdler Sharpe, four lectures on the geographical distribution of birds; Mr. James Swinburne, three lectures on some applications of electricity to chemistry (the Tyndall lectures). The Friday evening meetings were resumed on April 14, when a discourse was given by Sir William H. Flower, on seals. Succeeding discourses will probably be given by Prof. A. B. W. Kennedy, Prof. Francis Gotch, Mr. Shelford Bidwell, the Right Hon. Lord Kelvin, Mr. Alfred Austin, Mr. Beerbohm Tree, Prof. Osborne Reynolds, Prof. T. E. Thorpe, and others.

The reported discovery of Prof. Emmerich, that the blood of an animal which has recovered from an infectious disease can cure another animal suffering from the same disease, seems likely to prove of considerable importance. At the last meeting of the Berlin Physiological Society some remarkable statements regarding the facts arrived at were made. Mice had been inoculated by the serum or watery portion of a horse's blood, the horse having been already cured of the disease; the result was that the mice, which had been previously inoculated with the bacilli of lock-jaw, did not die when subjected to the treatment, while those left to themselves perished. Experiments are to be tried on human beings.

In a recent lecture at the Royal Institution, Dr. E. Hopkinson remarked that the engineer only begins to realize the imperfections of all his works when he contemplates the amount of energy involved in his final purpose compared with the energy of the coal with which he starts. Beginning with the energy in a pound of coal, and tracing its loss step by step, it appears that in the case of the most economical electric railway, the energy expended on the passenger is but little more than one per cent. of the energy produced by the burning of the coal. Even this result is better than lighting with incandescent lamps, in which only about one-half per cent. of the original source of energy is utilized. When we consider that, both in transportation and lighting, more than ninety-nine parts in a hundred are now wasted, it will be seen that the future has great possibilities.

Prof. Bonney, F.R.S., in his paper read before the Royal Geographical Society on "Do Glaciers excavate?" made a vigorous attack on the theories of Sir A. Ramsay's school, which attribute to glacial action the great lakes or rock-basins of Switzerland and elsewhere, sometimes more than 1000 feet deep. His investigations as to the action of moving glaciers from 1860 to 1890 seem to show that they do little more than modify existing features of the land, rounding off prominences, scraping up gravel, and so on. Prof. Bonney's theory of the origin of rock-basins, which he brought forward twenty years ago, is that lake beds are ordinary valleys of sub-aërial erosion, affected by differential earth-movements. In support of this view he quotes many different surveys; that of the great lakes of America serving especially to confirm it. The beach of the Iroquois, for instance, is 600 feet higher at the north-east part than it is at the western end of Lake Ontario.

At a meeting of the Royal Geographical Society on Monday, March 13th, Mr. H. O. Forbes, a well-known naturalist, discussed in an illustrated lecture the question of the former extension of an Antartic continent in relation to certain observations made during a recent visit to the Chatham Islands. He found there the remains of a large and remarkable bird, a member of the rail family, viz., the aphanapteryx, which lived contemporaneously with the celebrated dodo in the island of Mauritius, and was very similar to one of the extinct flightless birds of that island. In the Chatham Islands there still live several types of flightless birds scarcely represented elsewhere, except in widely separated oceanic islands; and to account for their distribution it is necessary to assume very different geographical conditions from the present. An animated discussion followed. Dr. Slater was against a former Antartic continent; Dr. Henry Woodward, Dr. Gunter, and others, spoke in its favour; and the soundings of the Southern Ocean, so far, confirm the view advocated by Messrs. Forbes, Wallace, Blandford, and others.

XUM

A set of rules for estimating the quality of vulcanized caoutchouc have been drawn up by M. Vladimiroft, and are adopted in Russian naval stores. Briefly, the criteria are as follows:— (1) Caoutchouc should not give the least sign of cracking when bent to an angle of 180°, after five hours' exposure in an air bath at 125° C. (2) Caoutchouc having not more than half its weight of metallic oxides should bear stretching five times its length before rupture. (3) Caoutchouc, exempt from all foreign matter except sulphur, should be capable of stretching at least seven times its length before rupture. (4) The extension measured just after rupture should not exceed twelve per cent. of the original length. (5) Suppleness may be determined by calculating the percentage of ash after incineration. This may form the basis of choice for certain uses. (6) Vulcanized caoutchouc should not harden in cold.

Astronomy and Astro-Physics (for April) says that Mr. James E. Keeler has made a series of observations of the spectrum of the interesting variable star β Lyræ, using the Lick Observatory 36-inch telescope. The following conclusions seem to be warranted by the observations:— (1) In the spectrum of β Lyræ the bright hydrogen lines C and F, the bright D_3 line, and the dark D lines are constantly visible with a telescope as large as the Lick refractor. Certain fainter bright lines become invisible at the time of a principal minimum. (2) The variations in the light of the star are principally due to changes in the brightness of the continuous spectrum. (3) The bright lines are brightest when the continuous spectrum is brightest. (4) The bright lines are broad and diffuse, particularly when the star is at a maximum. The D lines are very hazy, so that the components are hardly distinguishable. (5) During the greater part of the period of the star no remarkable changes occur in the appearance of the spectrum. The observations fail to show any connection between changes in the spectrum and the secondary minimum of the star. (6) The most remarkable changes take place at the time of a principal minimum. The bright lines become dimmer, and perhaps sharper, and the fainter bright lines disappear. The D lines become darker. Strong absorption lines appear on the more refrangible side of certain bright lines in the green, the separation of the dark and bright lines being at least five-tenth metres. Other bright lines are perhaps similarly affected. A narrow dark line appears above the D_3 line at the same time. Shortly before the first maximum is reached the dark lines disappear.

DEEP SEA DEPOSITS.

By Rev. H. N. Hutchinson, B.A., F.G.S., *Author of "Extinct Monsters," &c.*

[Third Paper.]

With the exception of the red clay, described in our last paper, the famous *globigerina ooze* is the most widely distributed of all marine deposits. It occupies the greater part of the Atlantic, and a good deal of the Indian, Pacific, and Southern Oceans. Its total area is estimated at 49,520,000 square miles. Examination of Chart I. (p. 44) shows that it occupies all the medium depths of the ocean removed from continents and islands, and that it is especially developed in those regions where the surface of the sea is occupied by warm currents. The patch in the Norwegian Sea is evidently due to the northward extension of the Gulf Stream. The first specimens of this ooze were obtained by Lieut. Berryman, United States Navy, in the North Atlantic, and were described in detail by Ehrenberg and Bailey in 1853.

As we have before remarked, there is a difficulty in drawing hard and fast lines on a chart to mark off the geographical areas of one deposit from those of another; and the reason of this is that to some extent they merge into each other. The question is, where to draw the line. For example, were all deposits containing only ten or fifteen per cent. of foraminifera to be classified as globigerina ooze, then this deposit would be found to be by far the most widely distributed of all the deep sea deposits. In *all* types of marine deposits, and in all latitudes, some species of these shells are present in greater or less abundance.

Messrs. Murray and Renard, however, draw the line at thirty per cent. or more of carbonate of lime; and any deposit having so much lime, or more, is put down in their report as globigerina ooze. There was at one time a good deal of uncertainty as to whether the foraminifera that chiefly go to make up the lime in this deposit lived at the surface or on the sea floor; but, after some years of doubt, it has been definitely settled that most of them lived at or near the surface. To those who are familiar with the protozoa it may be interesting to know that among the pelagic foraminifera taken in surface nets during the cruise of the *Challenger* were: globigerina (ten species), orbulina (one species), pulvinulina (five species), hastigerina* (one species), pullenia (one species). The majority of these species are limited to those deposits immediately under warm tropical waters, and only a few of them were met with in deposits dredged up from the colder regions of the ocean.

The *Challenger* naturalists found the deposit ranging in depth from 400 to 2925 fathoms (giving an average depth of 2002 fathoms); 118 samples were examined. We may say that it is most typically developed at 2000 fathoms. At greater depths than 2500 fathoms the carbonate of lime is gradually removed, the ooze becoming darker in colour until finally it gives place to a red clay. In the Atlantic, we find it covering the submarine ridges and elevated plateaux, and it borders the upper zone of the oceanic abysmal area. Its prevailing colour, far from land, is milky white or rose colour, and near land, dirty white, blue or grey. Sometimes it has a mottled appearance, due to the presence of manganese grains, volcanic ashes, pumice, &c. In tropical regions, where warmth favours growth, the foraminifera are often large enough to be visible to the naked

* Extract from Wyville Thomson:—"*The Atlantic*," Vol. II., p. 293.

62*a*., *Living Hastigerina*.—"On one occasion, in the Pacific, when Mr. Murray was out in a boat in a dead calm collecting surface creatures, he took gently up in a spoon a little globular gelatinous mass with a red centre, and transferred it to a tube. This globule gave us our first and last chance of seeing what a pelagic foraminifer really is when in its full beauty. When placed under the microscope, it proved to be a hastigerina in a condition wholly different from anything which we had yet seen. The spines, which were mostly unbroken, owing to its mode of capture, were enormously long, about 15 times the diameter of the shell in length; the sarcode, loaded with its yellow oil-cells, was almost all outside the shell; beyond the fringe of yellow sarcode the space between the spines, to a distance of about twice the diameter of the shell all round, was completely filled up with delicate bullæ, like those which we see in some of the Radiolarians, as if the most perfectly transparent portion of the sarcode had been blown out into a delicate froth of bubbles of uniform size along the spines; fine double threads of transparent sarcode, loaded with minute granules, coursed up one side and down the other, while between the spines, independent thread-like pseudopodia ran out, some of them perfectly free, and others anastomizing with one another or joining the sarcodic sheaths of the spines, but all showing the characteristic flowing movement of living protoplasm."

XUM

PHOTOGRAPH OF MADREPORE LAGOON, FRINGING REEF, PORT DENISON.

Reproduced from "The Great Barrier Reef of Australia," by W. Saville-Kent, F.L.S., F.Z.S., &c.

Direct Photo Engraving Company, 9, Barnsbury Park.

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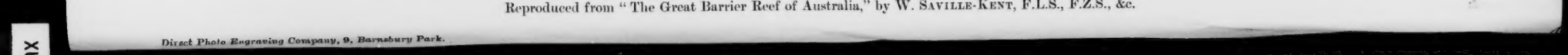

Reproduced from "The Great Barrier Reef of Australia," by W. Saville-Kent, F.L.S., F.Z.S., &c.

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eye. It is, perhaps, hardly necessary to remark that the carbonate of lime in this deposit is not all due to foraminifera, for many other organisms contribute calcareous material, some living on the surface waters, and others on the sea bed. Thus we find that remains of molluscs, echinoderms, annelids, corals, and polyzoa were nearly always met with in dredging up samples of this ooze. Sometimes, in tropical or sub-tropical regions, the shells of *pteropods** and *heteropods* were found in great abundance, and then the globigerina ooze passes into a pteropod ooze (see Chart I). The well-known coccoliths and rhabdoliths are often abundant, and sometimes make up as much as 15 per cent. of the deposit. These curious minute organisms, which a few years ago were a puzzle to naturalists, are now regarded as calcareous pelagic algæ. Remains of the radiolaria, diatoms, and siliceous sponges are almost always present.

Life is much more abundant on the globigerina ooze areas than on those of the red clay or radiolarian ooze. Where the former ooze occurs, numerous animals (fishes and invertebrates) were dredged up. Of the 118 samples reported on by the *Challenger* naturalists, pelagic foraminifera made up on the average 53 per cent., and other organisms 9 per cent.; the bottom-living foraminifera were only over 2 per cent.

Pteropod Ooze.—Although the remains of pteropods are abundant everywhere in the surface waters of tropical and sub-tropical regions, yet there dead shells are wholly absent from the deposits in all the deeper waters. The reason of this is that the delicate shells expose a large surface to the sea water as they fall through it, and are therefore dissolved before they reach the bottom where it is deep. Pteropod ooze abounds on submarine ridges that rise to within 1000 fathoms of the surface. A few traces were sometimes met with at 2000 fathoms, but only in lesser depths do they make up any appreciable part of the globigerina ooze. In all deposits near continents and islands, where tropical oceanic waters occupy the surface, heteropod and pteropod shells are more or less abundant. Thirteen samples are described in the *Challenger* report, with an average depth of 1044 fathoms. Foraminifera made up about 50 per cent. It differs from globigerina ooze in the larger amount of carbonate of lime, due to the delicate pteropod shells. It is most typically developed on the central ridges of the Atlantic, where the depth is not more than 1000 fathoms or so (see Chart I). It is to be met with off the West Indies, the Azores, and some of the Fiji Islands. Many inter-tropical islands are apparently surrounded by this deposit.

We now pass on to *terrigenous deposits*. Omitting the coarser deposits of sand and shingle beds nearer shore, we have now to deal with fine detrital matter beyond the 100 fathom line. All these deposits are laid down on what may be called the continental slope, or that area extending from the 100 fathom line down to the ocean basins, where they merge into pelagic deposits.

Blue Mud.—This deposit is particularly interesting to the geologist, because it throws light upon the history of the numerous formations of slate, shale, and clay found in the series of stratified rocks. It is met with in the deeper waters round continental land, and in all enclosed seas, partly cut off from the open ocean. It is, of course, a product of the land denudation. Its blue colour is due to chemical changes produced by decomposing vegetable and animal substances, in presence of the sulphates of sea-water, which are reduced to sulphides and decompose the ferric oxide abounding in all deposits into sulphide of iron and ferrous oxide. Blue muds smell of sulphuretted hydrogen. Fifty-eight samples are described, with an average depth of 1411 fathoms. In some cases pelagic foraminifera make up 25 per cent. of the deposit, while in others there is no trace of them. Rounded grains of quartz are abundant. The mineral particles are mostly derived from adjacent land. Blue muds surround nearly all the coasts and fill most enclosed seas like the Mediterranean.

Red Mud.—Along the Brazilian coasts of South America the terrigenous deposits differ from other such in being reddish instead of blue or green. The cause of this is to be found in the large amount of ochreous matter brought down by the Amazons, Orinoco, and other South American rivers, and distributed by ocean currents. Probably there is not enough organic matter to reduce the whole of the iron peroxide to protoxide, nor does the sulphide of iron accumulate here. Similar red muds are met with off the Chinese coast, near the mouth of the Yang-tse-Kiang.

Green Muds and Sands.—These deposits are chiefly characterized by the presence of glauconitic grains and casts of calcareous organisms. They are generally met with along bold exposed coasts where no very large rivers pour their detrital matters into the sea. They do not occur in very deep water (usual depth, 100—900 fathoms). In these regions pelagic deposits are found to approach much nearer to the shores than where the blue muds prevail. So much is this the case that were it not for the grains of glauconite (a greenish mineral) they might be taken for globigerina ooze. *Green Sands* were found in rather shallower waters (average depth, 449 fathoms). Foraminifera make up 36 per cent. of the deposit. This glauconite appears to be precipitated inside the foraminiferal shells, thus forming casts of their interiors which remain after the shells have been dissolved. The chemistry of the ocean is at present little understood, but it is suggested that the glauconite may be the result of chemical changes undergone (in the presence of organic matter) by finely divided particles derived from land.

Volcanic Muds and Sands.—Oceanic islands of volcanic origin are surrounded by volcanic muds or sands formed by the wearing down of volcanic rock and its subsequent partial decomposition by the chemical action of sea water, the fragments of shells which are present being often coated with peroxide of manganese. Near shore, within the region of wave action, the deposits are mostly sands, mixed with fragments of calcareous organisms. They vary in colour, being grey, brown or black, and pass in some places into muds, or coral sands, or, with greater depth, into oozes; thirty-eight samples of volcanic muds are described, with an average depth of 1033 fathoms. Volcanic sands chiefly differ in the absence of the fine clayey and calcareous matter so abundant in the muds.

Coral Muds and Sands are formed from the débris of structures such as are shown in our plate, copied by the kind permission of Mr. Saville-Kent from one of the illustrations in his work on "The Great Barrier Reef of Australia." Several forms of coral are shown in this plate, with masses of madrepore and the shrub-like growth known as stag's-horn coral. Around such coral reefs the deposits are chiefly made up of fragments of organisms living in shallow water—such as algæ, corals, molluscs, polyzoa, annelids, echinoderms, and foraminifera. As might be expected in shallower waters, these form a coarse sand or gravel; but beyond the limits of wave-action there is a fine mud consisting principally of ground-up calcareous matter. As we get further away from the reefs and in deeper water, the deposits gradually pass into some kind of ooze. Sixteen

* The class Pteropoda are small free-swimming molluscs, found on the surface of the ocean, often in enormous numbers. They are lower down in the scale of life than the Gastropoda, and represent the transient larval stage of sea-snails. The Heteropoda are also pelagic and free-swimming, but may or may not have a shell.

samples of coral mud were obtained (average depth 740 fathoms). In colour they were various shades of white, and they contain a very large percentage of carbonate of lime (about 87 per cent.).

In coral sands the fragments of organisms are larger, and the depth is less. Coral muds and sands cover a large area (see Chart I.). Geologists find analogues of these deposits in some of the jurassic limestones, such as the Bath freestone and the coral rag. The most extensive coral region is that of the Pacific Ocean.

The following table shows at a glance the relative areas occupied by the different deposits, and the depths at which they occur :—

		Mean Depth.	Square Miles.
Littoral deposits (between tide marks)			62,500
Shallow water deposits (from low water mark to 100 fathoms)			10,000,000
Terrigenous deposits (in deep and shallow water close to land).	Coral Mud	740)	2,556,800
	Coral Sand	176) ...	
	Volcanic Mud ...	1033)	600,000
	Volcanic Sand ...	243) ...	
	Green Mud	513)	850,000
	Green Sand	449) ...	
	Red Mud	623 ...	100,000
	Blue Mud	1411 ...	14,500,000
Pelagic deposits (in deep water far removed from land).	Pteropod Ooze ...	1044 ...	400,000
	Globigerina Ooze ...	1996 ...	49,520,000
	Diatom Ooze	1477 ...	10,880,000
	Radiolarian Ooze ...	2894 ...	2,290,000
	Red Clay	2730 ...	51,500,000

A word about the volcanic products, so widely distributed, and the chemical changes they are supposed to have undergone. Messrs. Murray and Renard have much to say on this subject, and they arrived at the conclusion that the manganese nodules they so frequently dredged up on red clay areas are the result of the chemical alteration of volcanic débris. But perhaps it will be wise not to accept this conclusion as final. Pumice stones occur in great numbers near volcanic centres, *e.g.*, off the Azores. They vary in size from that of a pea to the size of a football. They are most abundant in deep sea clays, from which the shells and skeletons of surface organisms have been removed by solution ; and are more numerous in the Pacific than in the Atlantic. They have a rolled appearance, and have evidently undergone much decomposition. Peroxide of manganese occurs widely as nodules and incrustations on the sea floor. It is a significant fact that the manganese is in greatest abundance where there have been showers of volcanic ash, and hence it seems likely that it may be a secondary product of the decomposition of volcanic minerals. In the manganese contained in lavas and the carbonic acid of ocean waters we seem to have the requisite means for the decomposition of pumice, the solution of the manganese, and its deposition as peroxide. In some places the nodules distinctly show periods of deposition.

In conclusion, the work of the *Challenger* expedition has brought to light a fact of great geological interest ; for when the deposits now forming are compared with the stratified rocks in which the geological record is contained, it is found that the latter are very similar to those forming in shallow water and *not to the deep sea deposits*—at least, not to those of the deeper depressions of the sea floor. Even the chalk formation, which in some points so much resembles globigerina ooze, presents some important differences, and was probably formed in rather shallower water. Again, rocks resembling the red clay are (with one exception) conspicuously absent from the stratified series. That exception is the "red earth" of Bermuda, which must be accounted for by a volcanic upheaval. In view of these facts many geologists have adopted the theory of "the permanence of ocean basins" as the only satisfactory explanation. In other words, they believe that the great earth-movements of the past have been confined to the continental areas and the shallow waters by which they are bordered. No doubt there is much to be said for this theory ; but then abysmal deposits like the red clay may yet be discovered in the rocks of new countries. We cannot stop to discuss this interesting question now, but will only point out that it is difficult to see why the abysmal areas should be always sinking and never rising.

ON CERTAIN LOW-LYING METEORS.

By Charles Tomlinson, F.R.S., F.C.S., &c.

II.—Phosphorescent Meteors.

During the putrefaction of animal matter a gas may be given off which enters into combustion with the oxygen of the air. This gas, as prepared by the chemist, is a compound of three parts of hydrogen with one of phosphorus ; but as seen in Nature, it is largely diluted with air, and then appears, if at all, with a glow more or less feeble. Thus, about the year 1860, the town of Thurso, in the north of Scotland, was thrown into a state of alarm by a luminous appearance which was seen during several nights in an adjoining plantation. It was supposed to be a ghost or spectre, and people preferred to go a long way out of their road rather than pass near it. At length a few bold spirits formed a committee of inquiry, and proceeded one night towards the spot, but on a nearer approach imagination had made the spectre appear so terrible that they all turned tail and retreated home—all but one brave hero, who determined to face the awful apparition, and he advanced up to the very tree that exhibited it, when he found that the light proceeded from a large fish which someone had thrown up into the tree, and this, in decomposing, had generated sufficient phosphuretted hydrogen to produce a luminous glow.

Many years ago the Curator of the Natural History Museum at Geneva had collected a considerable quantity of impure alcohol, which had been used for the preservation of fishes and other specimens. This alcohol was sent to a pharmacist with instructions to purify it and return it. He accordingly mixed it with chloride of calcium and quicklime, and distilled it. Having thus separated the alcohol from its impurities, he proceeded to expose the residue to the open air, in order to recover the chloride of calcium by evaporating the watery liquid ; but when this had attained a syrupy consistence it began to pour off torrents of phosphuretted hydrogen. This lasted many hours and did not cease until the mass had become completely dry.

The phosphorus in the above case was derived from the fishes and other animals that had been preserved in the alcohol. In the process adopted for purifying the latter a phosphuret of lime had been formed. This is a compound well known to the chemist, who prepares it by distilling phosphorus over lime heated to redness. Its modern name is calcic phosphide. When a cold lump of it is thrown into water it becomes decomposed, and gives off bubbles of phosphuretted hydrogen. Each bubble as it bursts takes fire on contact with the oxygen of the atmosphere, and produces a white wreath of phosphoric acid, made up of a number of ringlets revolving in vertical planes round the axis of the wreath as it ascends with beautiful effect.

Such appearances as these do not, however, belong to low-lying phosphorescent meteors. In their most vivid form they present only a glow. In churchyards and other burial places the phosphorus of the animal body during decomposition in the presence of moisture may form

phosphuretted hydrogen in small quantities, which, streaming up into the atmosphere, may present that faint appearance known as a *corpse-candle*. In Wales an appearance of this kind was said to denote a coming funeral, and few of the people of Carmarthen formerly died without having seen their *death-light*, just as in other parts, Northumberland for example, some people saw their *waff* or *whiff* as a death token, which is similar to the Scotch *wraith*, or the appearance of a living person to himself or others. Many years ago the Austrian chemist Von Reichenbach examined a number of patients in various parts of Germany and Austria who were very sensitive to the action of light. On taking one of these by night into a churchyard, he declared that every grave was luminous.

A very sensitive eye is required to see these corpse-candles, and we need not be surprised that a good deal of superstition is connected with them. But phosphorescent meteors, as well as light carburetted hydrogen meteors, are now rarely seen. The latter have been extinguished by drainage and agriculture, and if the former occasionally appear, they do not attract much attention now that their nature is understood and their advent accounted for.

III.—Electrical Meteors.

But if the two former kinds of meteors are now but rarely seen, those of the third kind frequently appear, and are likely to continue to do so, since they belong to one of the great forces of Nature which is always active and everywhere present, while the other two are natural indeed, but local and accidental in their action.

In 1752 Franklin, by his famous kite experiment, proved the identity of lightning with common electricity. The action of a thunder-cloud is to throw by induction a portion of the earth's surface lying beneath it into an opposite electrical state. If the cloud be positive or +, the earth will be negative or −. This change is brought about by the polarization of the intervening air; that is, the upper half becomes −, the lower half +, and so throughout, until the + half of the lowest particle throws the earth into an opposite or − state. Supposing this action to go on among the innumerable particles of the dielectric or non-conducting air that separate the cloud from the earth, the + half of each particle becomes more +, and the − half more −, until the strain or tension is such that the system breaks down, and a disruptive discharge of electricity takes place between the cloud and the earth.

Soon after Franklin's experiment it was discovered that the electrical condition of the air did not depend on the action of a thunder-cloud, but that in different states of the weather, under a cloudy or a clear sky, the air is sensibly electric. In fine weather the air is + and the ground −, and in the course of the twenty-four hours certain variations take place, consisting of two maxima and two minima. The former are probably due to the conducting property of moisture, which brings down electricity from the upper regions, while the dispersion of that moisture by the heat of the sun seems to give occasion to the minima. The electricity of rain, snow, hail and fog is sometimes + and sometimes −.

But there are occasions when atmospheric electricity assumes a high potential, and gives rise to many curious and interesting effects, so varied that I cannot do much more than glance at them. One typical case, however, may admit of some little detail; it is related in the "Memoirs of General Marbot," published a year or two ago. The general accompanied Napoleon the First in his invasion of Russia, and during the retreat of his cavalry regiment he saw before him one night a number of lights, which he mistook for the bivouac fires of the enemy. He sent out scouts to ascertain what force lay before him, and it was reported at 50,000, while he had less than 700 men. While debating what course to pursue, the lights began to appear on his own men. He at once recognized them as *feux follets*, a term applied by the French to low-lying meteors before their origin was understood. The general's explanation of the phenomenon cannot be accepted. He had already remarked that a marsh over which he had passed was dry, and yet he accounts for the meteor by supposing it to have been produced by the emanations of the marsh condensed by a slight frost after a hot autumn day. "En peu de temps le régiment fut couvert de ces feux gros comme des œufs, ce qui amusa beaucoup les soldats."

The general's account was written from recollection long after the event described, and may thus have been unintentionally embroidered. The imagination of the scouts who mistook the lights for the bivouac fires of a large army, and the dazed sight of the general, who saw *des milliers de feux* suddenly cover the ground he had lately quitted, were natural exaggerations. The ground just quitted he described as *situé dans un bas fond, sur un très vaste marais desséché*. Hence the marsh, being dry, could not furnish an inflammable gas, and even had it done so and the gas been set on fire, the flames would not have appeared first on the hills, and afterwards in the plain, nor could they have been seen playing upon the soldiers. The phenomena are, however, quite consistent with what is known of electrical action, a similar example of which is related by Arago as having occurred to some French engineer officers in Algiers on the evening of the 8th May, 1831. They were walking with uncovered heads on a terrace, when the hair of each stood on end, and little jets of electric light issued from them. When the officers raised their hands, similar jets played upon their fingers.

Such phenomena as these formerly struck terror into men's minds, and we ought to be grateful to science for reducing them under natural laws. Shakspeare, in his tragedy of *Julius Cæsar*, describes with his usual graphic power the phenomena, and the feeling excited by them. Casca exclaims :—

> "Either there is a civil strife in heaven,
> Or else the world, too saucy with the gods,
> Incenses them to send destruction.
> * * * * A common slave
> Held up his left hand, which did flame and burn
> Like twenty torches join'd, and yet his hand,
> Not sensible of fire, remained unscorch'd.
> * * * * And there were drawn
> Upon a heap a hundred ghastly women,
> Transformed with their fear, who swore they saw
> Men all in fire walk up and down the streets."

What Casca thus graphically described, and accompanied with so much horror, now belongs to the order of natural phenomena. In June, 1880, at Clarens, near the Lake of Geneva, the air in the afternoon of the 17th was in a very excited state, and a cherry tree, measuring about a yard in circumference, was struck by lightning, and shivered into matches. A little girl who had been gathering cherries, and was now about thirty paces from the tree, appeared to be literally wrapped in a sheet of fire. Some men who were working in a vineyard close by saw the electricity play about her, but they fled in terror from the spot. In a cemetery close by, six persons, separated into three groups, none of them within 250 paces of the cherry tree, were enveloped in a luminous cloud. They said they felt as if they were being struck in the face with hailstones or fine gravel, and when they touched each other sparks passed from their fingers' ends. At the same time a luminous column was seen to descend, and the electricity was distinctly heard as it ran from point to point of an iron railing in the cemetery. None of the persons referred to were hurt; they only complained of an unpleasant

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sensation in the joints, as if they had been violently twisted, a sensation which lasted for a few hours.

Many of the effects of atmospheric electricity depend upon that kind of discharge known as the *brush* and the *glow*, both of which, according to Faraday, consist of a charging of air, the only difference being that the *glow* has a continuous appearance from the constant renewal of the same action in the same place, whereas the *brush* ramification is due to a momentary independent and intermitting action of the same kind. In other words, a continuous discharge to the air gives the *glow*, an interrupted one produces the *brush*, with a kind of subdued roaring noise, while in a more exalted electrical condition we have the spark.

The brush discharge may often be seen playing on pointed bodies, as on the spears of Cæsar's legion, and in this mild form it did not produce the terror of the more energetic display already referred to. In later times, when it appeared at the extremities of the masts of ships, it was hailed as a good omen, and was known to the French and Spaniards as *St. Elmo's* or *Helmo's Fire*: to the Italians as the *Fires of St. Peter and St. Nicholas*: to the Portuguese as *Corpos Santos*, which the English sailors have corrupted into *Comazants*.

Such a phenomenon is referred to by De Saussure in the lighting up of the rocks at night, and the motion of electricity over the prairies of America. It has been compared to a miniature lightning discharge, resulting from the electrified cloud brushing over the earth, and discharging itself by thousands of sparks. In Switzerland the discharge sometimes produces loud rattling or crepitation of the stones. On the summit of Piz Turley De Saussure experienced pricking and burning sensations, and heard sounds like simmering water, emitted by sticks laid against the rocks, or by the vibrations of the alpenstocks. Professor James Forbes, while on one occasion on Mont Cervin, at an elevation of about 9000 feet above the sea level, noticed a curious sound, which seemed to proceed from his alpenstock. He asked the guide whether he heard it, and what he thought it was. "The members of that fraternity," he remarks, "are very hard pressed indeed when they have not an answer for any emergency. He therefore replied with great coolness that the rustling of the stick no doubt proceeded from a worm eating the wood in the interior." On reversing the stick, the worm was already at the other end. He next held up his fingers above his head, and they yielded a fizzing sound. There was only one explanation: the party was so near a thunder-cloud as to be highly electrified by induction. All the angular stones near them were hissing like points near a powerful electrical machine.

It is not necessary, however, that a thunder-cloud should be present to account for a similar excited state of the atmosphere when Livingstone was on the borders of the Kaluhari Desert. During the dry seasons that succeed the winter and precede the rains a hot wind occasionally blows from north to south. This wind is in such an excited state that a bunch of ostrich feathers held for a few seconds against it becomes as strongly charged as if it had been attached to a powerful electrical machine, and clasps the advancing hand with a sharp crackling sound. When this hot wind is blowing, and even at other times, the peculiarly strong electric state of the air causes the movement of a native in his *kaross* to produce a stream of small sparks. "The first time," says Livingstone, "that I noticed this appearance was when a chief was travelling with me in my wagon. Seeing part of the fur of his mantle, which was exposed to slight friction by the movement of the wagon assume quite a luminous appearance, I rubbed it smartly with the hand, and found it readily give out bright sparks, accompanied with distinct cracks. 'Don't you see this?' said I. 'The white man did not show us this,' he replied; 'we had it long before white men came into the country, we and our forefathers of old!'"

Another form of low-lying electrical meteors is known as *globular* or *ball* lightning (*éclairs en boule*). A celebrated case of this kind was reported in the *Philosophical Transactions* of the Royal Society about the middle of the last century. Mr. Chalmers states that being on board the *Montague* (seventy-four guns), on November 4th, 1749, he observed a large ball of blue fire rolling along on the surface of the water as big as a mill-stone, at about three miles distant. Before they could raise the main-tack the ball had reached within forty yards of the main chains, when it rose perpendicularly, with a fearful explosion, and shattered the main topmast in pieces. So also on the Malvern Hills, in June, 1826, what was called "a ball of fire" was observed to roll along the hill towards a building where some people had taken shelter; here it exploded, and killed two of them.

These luminous balls seem to be the result of a brush discharge on a large scale. In the case of the *Montague*, the ball was seen rolling on the surface of the water towards the ship from to windward. The discharge was produced by some of the polarized atmospheric particles yielding up their electricity to the surface of the water. On nearing the ship, the point of discharge became transferred to the head of the mast; and the striking distance being thus diminished, the whole system returned to its normal state, that is to say, a disruptive discharge ensued between the sea and the clouds, producing the usual phenomena of lightning and thunder, or as it was described by the observers, "the rising of the ball through the mast of the ship." The case on the Malvern Hills is another instance of the same kind.

Another case of glow discharge was reported by Mr. Jabez Brown in a letter to the *Times*, dated Boscastle, December 1st, 1858. He says:—"Last night at fifteen minutes to nine, ascending one of the sharp hills of this neighbourhood, I was suddenly surrounded by a bright and powerful light, which passed me a little quicker than the ordinary pace of a man's walking, leaving it dark as before. The light was seen by the sailors in the harbour coming in from the sea, and passing up the valley like a low cloud."

Some electricians doubt whether these balls of electric fire have ever been seen within doors. Such cases, however, have been reported on good authority. Thus M. Trécul, in a note to the *Comptes Rendus*, states that on the 18th August, 1876, while writing at an open window between 7 and 8 a.m., he observed simultaneously with some loud thunder, small luminous columns descend obliquely on his paper, about two mètres long, and half a decimètre broad at the widest part; obtuse at the further end, but gradually thinning towards the table. They had mostly a reddish-yellow tint, but near the paper the tints were more intense and varied. In disappearing they left the paper with a slight noise like that produced by pouring a little water on a hot plate.

Arago relates a case of globular lightning within the walls of a building as reported by Maffei as occurring in September, 1713, in the territory of Massa-Canara, in Italy. He took refuge from a storm in a chateau, where he was received by the mistress of the house in a room on the ground floor. Suddenly they saw a bluish-white flame rise from the floor; it was agitated, but had no progressive motion. After gradually acquiring a considerable volume, it suddenly disappeared. Maffei felt in his shoulder a

peculiar tickling sensation, some plaster detached from the ceiling fell upon his head, and an explosion occurred which did not resemble the sound of thunder.

A case is recorded in Mr. Symons' *Meteorological Magazine* for 1883 as having occurred on July 28th, about 6 p.m., in the printing office of Mr. Burt, Mount Washington, New Hampshire, U.S. Mr. Burt says:—"I saw a ball of fire as large as a man's head in front of me, not three feet off. It exploded with a tremendous noise, my left leg seemed to be completely paralysed, and I fell to the floor. Three of my printers were in the room at the time, two sitting at the table near me, and one standing up a little farther off. The latter had the skin of one hand torn, another was hit in the back, and the third escaped without injury." A tree-like mark was found on Mr. Burt's back, a not unusual figure impressed by the fiery hand of the meteor.

In conclusion, it will be seen that notwithstanding the mistakes made in the cyclopædias already referred to, it is quite possible to distinguish low-lying meteors as consisting of marsh-gas or of phosphuretted hydrogen, which are now of rare occurrence for reasons already given, while those of the third class, due to electricity, are of frequent occurrence, and will always continue to be observed.

THE FACE OF THE SKY FOR MAY.

By HERBERT SADLER, F.R.A.S.

SUNSPOTS are as prevalent as ever, some even having been visible lately to the naked eye. Conveniently observable minima of the Algol type variable δ Libræ occur at 10h. 4m. P.M. on the 2nd; at 9h. 37m. P.M. on the 9th; at 9h. 12m. P.M. on the 16th; at 8h. 46m. P.M. on the 23rd; and at 8h. 20m. P.M. on the 30th.

Only two of the major planets are observable this month, Mercury, Venus, Mars, Jupiter, and Neptune being, for the purposes of the amateur, quite invisible.

Saturn is an evening star, and is well situated for observation. He rises on the 1st at 3h. 48m. P.M., with a southern declination of 0° 22½′, and an apparent equatorial diameter of 18·6″ (the major axis of the ring system being 43″ in diameter, and the minor 4¾″). On the 15th he rises at 2h. 50m. P.M., with a southern declination of 0° 9′, and an apparent equatorial diameter of 18¼″ (the major axis of the ring system being 42¼″ in diameter, and the minor 4·6″). On the 31st he rises at 1h. 43m. P.M., with a southern declination of 0° 2¾′, and an apparent equatorial diameter of 17⅞″ (the major axis of the ring system being 41″ in diameter, and the minor 4·4″). He is occulted by the Moon on the 25th, but the phenomenon will only be visible in the southern hemisphere. Iapetus is in superior conjunction on the 3rd; Rhea at inferior conjunction at 10·5h. P.M. on the 4th; Titan at greatest eastern elongation at 0·8h. A.M. on the 13th; Rhea at inferior conjunction at 11·3h. P.M. the same evening; Rhea at inferior conjunction about midnight on the 22nd; Iapetus at greatest eastern elongation at 11h. P.M. on the 23rd; Titan at greatest eastern elongation at 11·4h. P.M. on the 28th. A map of the path of Saturn during May will be found in the "Face of the Sky" for March.

Uranus is an evening star, and but for his southern declination would be excellently situated for observation. He rises on the 1st at 6h. 50m. P.M., with a southern declination of 13° 56′, and an apparent diameter of 3·8″, the apparent star magnitude of the planet being 5·5 in the photometric scale. On the 31st he rises at 4h. 49m. P.M., with a southern declination of 13° 34′. A map of his path during May will be found in the "Face of the Sky" for April.

There are no well-marked showers of shooting stars in May.

The Moon enters her last quarter at 2h. 24m. A.M. on the 9th; is new at 10h. 47m. P.M. on the 15th; enters her first quarter at 2h. 52m. P.M. on the 22nd; and is full at 3h. 23m. P.M. on the 30th. She is in apogee at 6h. A.M. on the 3rd (distance from the earth 252,430 miles); in perigee at 7h. A.M. on the 16th (distance from the earth 222,090 miles), and in apogee again at 8h. A.M. on the 30th (distance from the earth 252,500 miles).

Chess Column.

By C. D. LOCOCK, B.A.Oxon.

ALL COMMUNICATIONS for this column should be addressed to the "CHESS EDITOR, *Knowledge Office*," and posted before the 10th of each month.

Solution of April Problem (A. G. Fellows):—

Key-move: 1. R to K8.

If 1. . . . Kt moves, 2. Q × Pch, &c.
If 1. . . . K to Q5, 2. Q to Ktsqch, &c.
If 1. . . . P to B5, 2. P × Pch, &c.
If 1. . . . P to K5, 2. B × Pch, &c.

CORRECT SOLUTIONS received from H. S. Brandreth, Alpha. Additional solution of March problem from J. E. Gore.

Alpha.—After the key-move which you sent to the March problem, there was *no mate* if Black replied 1. . . . Q × Pch. Hence the assumption that you "overlooked the check."

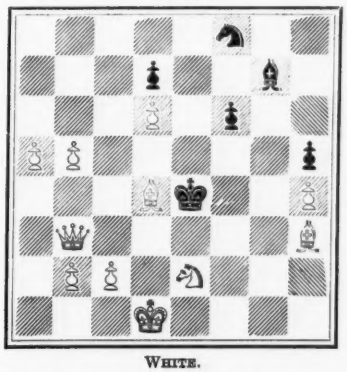
H. H. S.—Too late to reply to last month. (1) The address is: Mr. J. E. Whincop, 23, West Hillary Street, Leeds. Price 3s. 2d. post free. The "men" appear to be slips of ivory. (2) Either Gossip's "Theory of the Chess Openings," or Freeborough and Rankens' "Chess Openings, Ancient and Modern," of which a new edition is in the press. Both works are published at six or seven shillings. There are also two excellent shilling handbooks by J. Mortimer and G. H. D. Gossip respectively.

Adelaide Observer.—Received with thanks.

PROBLEM.

By G. K. ANSELL.

BLACK.



WHITE.

White to play, and mate in two moves.

The following game was played at board No. 1 in the Inter-Universities match last month :—

FRENCH DEFENCE.

WHITE (H. E. Atkins, Cambridge).	BLACK (R. G. Lynam, Oxford).
1. P to K4	1. P to K3
2. P to Q4	2. P to Q4
3. Kt to QB3	3. Kt to KB3
4. P to K5	4. Kt to Q2
5. P to B4 (*a*)	5. P to KKt3 (*b*)
6. Kt to B3	6. B to Kt2
7. B to Q3 (*c*)	7. P to QB4
8. P×P (*d*)	8. Kt×P
9. B to K3 (*e*)	9. Kt×Bch
10. Q×Kt	10. P to QR3 ? (*f*)
11. P to KR4 !	11. P to KR4 ?
12. Castles QR	12. P to QKt4 (*g*)
13. KR to Ktsq (*h*)	13. Kt to B3
14. P to KKt4	14. B to Kt2 (*i*)
15. K to Ktsq (*j*)	15. Q to R4
16. P×P	16. R×P (*k*)
17. R×P !	17. Kt to Kt5
18. R×Pch !	18. K to Q2 (*l*)
19. R to Q6ch	19. K to Ksq
20. Q to Q4	20. Kt to B3
21. Q to Kt6	21. R to Ktsq ?
22. R×Kt	Resigns.

NOTES.

(*a*) This, in conjunction with the previous move, constitutes Mr. Steinitz's attack.

(*b*) Quite out of keeping with the spirit of the defence. Black gives up the advantage on the Queen's side which he should get by 5. . . . P to QB4, 6. P×P, QKt to B3, without in any way strengthening his King's side. In fact, the move P to KKt3 not only gives a point of attack for White's KRP, but also weakens the effect of P to KB3, which is often a strong move for the defence.

(*c*) 7. B to K3 would prevent P to QB4 for the moment.

(*d*) 8. Kt to QKt5 is not much good, on account of the reply 8. . . . B to Bsq.

(*e*) Perhaps here, however, it was worth while to retire the Bishop to K2 first.

(*f*) Waste of time, apart from the extra power which it gives to the White Bishop. He should castle at once, or bring out one of his minor pieces. White's reply is probably intended to deter Black from castling. As a matter of fact it induces him to still further weaken his game.

(*g*) 12. . . . Kt to B3 at once was much better. The Knight might then be played *vid* K2 to KB4.

(*h*) Good enough; though 13. Kt to K4 looks also very strong.

(*i*) He has no time for this. Kt to K2 or Q to B2 was necessary.

(*j*) For White might perhaps have played at once 15. P×P, R×P; 16. R×P, Kt to Kt5; 17. R×Pch, K to Bsq; 18. B to B5ch, K to Ktsq; 19. B×Kt, P×R; 20. Kt to K4, with a strong attack. Mr. Atkins' move, however, is very deep. He intends in the above variation to meet . . . Kt to Kt5 by R×B !, recovering the Queen, as Black will no longer take it with a check.

(*k*) Curiously fatal now, owing to the position of his Queen. He should play . . . Kt to Kt5 at once.

(*l*) If 18. . . . K to Bsq, 19. B to B5ch, and 20. B×Kt, attacking the Queen.

CHESS INTELLIGENCE.

The Oxford and Cambridge chess match was played at the British Chess Club on March 24th. It will be seen from the score that Cambridge won by a handsome majority : though Mr. Hoffer, who adjudicated the unfinished games, is of opinion that, on the actual merits of the earlier portions of the games, Oxford should have at least drawn the match. In this match, each player was limited to one game for the first time. Clocks were successfully re-introduced.

OXFORD.	CAMBRIDGE.
1. Mr. R. G. Lynam, St. Cath. 0	Mr. H. E. Atkins, Peterhouse 1
2. Mr. G. H. Heginbottom, Pemb. 0	Mr. E. Young, Corpus 1
3. Mr. P. W. Sergeant, Trin. 1	Mr. J. H. Percival, Trin. H. 0
4. Mr. G. H. Cooper, Oriel... 0	Mr. C. E. Campbell, Trin. H. 1
5. Mr. E. W. Poynton, Exeter 0	Mr. P. Hart-Dyke, King's ... 1
6. Mr. E. Lawton, Corpus... 0	Mr. H. J. Snowden, Queen's 1
7. Mr. D. L. Secretan, Pemb. 0	Mr. L. W. Lewis, Peterhouse 1
1	6

Cambridge is now eight matches to the good.

The undecided game in the Hants *v.* Sussex match at Chichester was adjudicated in favour of Sussex, who thus won by seven games to six. The same county again defeated Kent in the return match at Ashford, the score being Sussex 9½, Kent 5½.

Possible encounters abroad this season are Lasker *v.* Showalter in America, and Tschigorin *v.* Walbrodt at Berlin or St. Petersburg. In the former case the amount of the stakes is the point at issue ; in the latter the scene of action, each player being naturally anxious to play in his own capital.

The long-expected Amateur Tournament at Cambridge took place early last month. The number of entries fell considerably below expectations. Messrs. Loman, Owen and Porterfield Rynd, who were regarded as certain to compete, failed to appear ; while Dr. Hunt, and Messrs. Locock and Miniati, who had also some thoughts of entering, were absent. In the end there were only five competitors, who decided, in view of their numerical weakness, to play two rounds. The result was as follows :—First prize, J. H. Blake (Southampton), 5½ ; second, W. H. Gunston, 4 (and one game unfinished). Mr. A. Dod (Liverpool) and the Rev. A. B. Skipworth (Horncastle) each scored 3½, and Dr. Deighton (Cambridge) 2½ (and one game unfinished) ; altogether a singularly even result.

CONTENTS OF No. 90.

	PAGE
Caterpillars' Dwellings—I. By E. A. Butler	61
Woodpeckers. By Harry F. Witherby	64
Deep Sea Deposits.—Second Paper. By the Rev. H. N. Hutchinson, B.A., F.G.S.	65
The Distribution of the Stars. By Miss A. M. Clerke	66
The η Argûs Nebula. By A. C. Ranyard	69
Science Notes	71
Letters :—R. Lydekker; Charles Nielsen; B. J. Hopkins; W. H. S. Monck; G. E. Mitton; Edwyn Anthony; W. Staniforth	73
The Constitution of Gases. By J. J. Stewart	75
The Face of the Sky for April. By Herbert Sadler, F.R.A.S.	78
Chess Column. By C. D. Locock, B.A. Oxon.	79

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